CHEMISTRY AND AGRICULTURE OF TEA,

INCLUDING

GROWTH AND MANUFACTURE.

M. KELWAY BAMBER.

A TEXT BOOK

ON THE

CHEMISTRY AND AGRICULTURE OF TEA

INCLUDING

THE GROWTH AND MANUFACTURE,

BY

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PREFACE.

In this work on the Chemistry and Agriculture of Tea, an endeavour has been made, without entering into the minute details of cultivation, &c., to lay before the Planter the main chemical and physical facts affecting all the processes included in the cultivation and manufacture, and to point out, where necessary, the means that may be adopted to increase or modify the natural influences at work.

A brief account is given of the original introduction of the plant from China as collated from Ball's "Cultivation and Manufacture of Tea," and Fortune's "Wanderings in China," and the discovery of the Indigenous Variety in Assam; also of the soils on which it is grown in the former country, in order to contrast them with those which have been selected for its growth in India.

The functions of the various parts of plants and their importance in the vegetable economy are fully dealt with to point out the effects of plucking, pruning and root cutting, and to show the necessity of performing these operations on scientific principles as well as in a practical manner.

As this book is chiefly the outcome of the investigations on tea soils and manures in 1891 and manufacture in 1892, it will probably be expected that certain manures will be recommended for application to particular soils, and as far as possible this has been done; but the experiments, which have been made, have not been sufficiently satisfactory, or conducted over a period long enough to warrant any more definite statements on this subject. The composition and relative value of different kinds of manure (chiefly those procurable in India) have been given to assist the planter in selecting those, which, if employed, would yield the most satisfactory results, and to prevent the useless expenditure of money on unsuitable material.

In dealing with the manufacture, I have necessarily been somewhat brief, as the experience that can be gained in only one season, and in a single district, is not sufficiently large to enable me to speak confidently on every phase of this subject in regard to all the districts where tea is grown, especially as climatic influences so largely affect the various processes employed; the chemical changes however induced in the manufacture have been explained, which should enable the planter to modify the latter according to his surroundings, and as his own experience may suggest.

I may here take the opportunity of expressing my sincere thanks to the planters of all districts for their kindness during my visits to their gardens, and to those who undertook manurial experiments at my suggestion ; and especially for the kind help so willingly given by the late Mr. W. M. Lawrie of Seleng, who placed at my disposal a suitable building for laboratory accommodation, and together with Mr. W. F. Perman afforded me every assistance in their power in the investigations carried out on that garden.

I would also tender my thanks and those of the Indian Tea Association, Calcutta, to the Government of India and to Dr. Warden for the valuable assistance afforded in allowing the use of the chemical laboratory at the Medical College, Calcutta for the examination of soils from the different tea districts.

The books and papers that have been consulted have been very numerous; and I would thank all those who have by their writings assisted me in the production of this book, and I am especially indebted for some valuable statements obtained from Professor Bentley's work on "Botany."

I hope that this book will be found of practical utility to Planters generally, not only in the manufacture of Tea, and in restoring the fertility of partially worn out soils, but also in preserving and utilising, in the most profitable manner, the natural fertility of land more recently brought under cultivation.

M. KELWAY BAMBER.

Kirkee, November 7th, 1893.

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HISTORY OF THE TEA PLANT.

CHAPTER I.

The earliest authentic account of tea, if anythiug so obscure and vague can be deemed authentic, is contained in the She King, one of the classical works of high antiquity and veneration among the Chinese, and compiled by their renowned philosopher, Confucius [born 550 B.C.]. Another author, Loyu, who lived in the Tang dynasty, A.D. 780, wrote a short and interesting treatise on tea, which contains a description of and treats of the qualities and effects of the plant, a subject which has occasioned much diversity of opinion in Europe and some even in China. After eulogising its fragrance and flavour, he observes :—

> " It tempers the spirits, and harmonises the mind : dispels " lassitude, and relieves fatigue : awakens thought, and " prevents drowsiness: lightens or refreshes the body, " and clears the perceptive faculties."

> " He also states that " all tea is gathered in the second, third " and fourth moons. The leaves must not be gathered " in rainy or even in cloudy weather, but when it is fair " and clear. Bruise and pat them with the hands ; " roast them over a fire (poey) ; pack and close them " up. In this manner tea is prepared ; and there are a " thousand and ten thousand different kinds."

It is obvious from the preceding account, that the Chinese were well acquainted with tea at this period, and we also find from other authorities that during the reign of Te Tsong in the same dynasty, the consumption of tea was already so considerable as to attract the notice of Government as an advantageous subject for impost. It is stated as a matter of history in the Kaung-moo, an abridged history of China, that a duty on tea was first levied in the fourteenth year of that reign, A.D. 783. In the dynasty of Sung, A.D. 960, the duty was again increased, and tea was first sent up as tribute, or as an annual offering to the Emperor : but prior to this, the Arabian travellers who passed into China in the ninth century, A.D. 850, speak of tea as the common beverage of the country.

Its origin as a beverage, according to the author of the Cha Pu, probably only commenced in the sixteenth century of the Christian era, although the plant was known to the Chinese as early as the third and fourth century of the Christian era, and was occasionally resorted to as a medicine ; it became abundant in the seventh and eighth, and general over the Empire in the ninth century.

The early mode of manipulation of tea is involved in much obscurity, but both prior and subsequent to the time of Loyu, allusion is made to the fact that tea was originally made into the form of cakes ; also to these cakes being ground to powder, and used as an infusion, sometimes as medicine, and sometimes at feasts and banquets ; in the latter case, perhaps with reference to its medicinal properties, as promoting digestion, or as stimulating the appetite.

The only mode of manipulation spoken of in early times is by the agency of steam. The leaves were steamed, some say, to extract a bitter water from them, then rolled with the hands or in cloths, and dried sometimes in the sun and sometimes over a charcoal fire, and finally reduced to powder to be formed into cakes. It does not appear however, whether the last process was always adopted, or whether the leaves were preserved entire and moulded into cakes or bricks.

There can be no doubt that the Pekoe tea was early known to the Chinese, and was much esteemed by them. Indeed they appear soon to have made the discovery, that the young and succulent leaves were the best : or as it is stated by them that "the convoluted bud of the leaf is the best, and other leaves in proportion as least developed," any imitation of this convoluted form for purposes of fraud or commercial advantage, would soon lead to a general introduction of the manipulation into leaf, if found a superior method, as is universally acknowledged.

It is not known at what period the processes of roasting and drying the leaves were introduced, but the superiority of these modes is acknowledged by the author of the Cha Pu, who observes, in the manipulation of tea, that,—"The leaves must be gathered just prior to the season of Koyu, picked clean and heated with steam. When they change colour, spread them out and fan off the steam with a fan ; then roll and dry them over a charcoal fire : and finally fold them up with the leaves of the Jo plant. It is said, that tea which is steamed in the first process is not so good as that which is roasted in an iron vessel : and in a second process, that which is sun-dried is not so good as that which is dried over a charcoal fire. So that which is first roasted in an iron vessel, and finally dried over a charcoal fire, is excellent." This latter method is the one now adopted in the black tea districts for the preparation of the best teas.

Regarding the early geographical distribution and discovery of the tea plant, the author of Cha Pu states, that the tea plant first attracted attention in the Vu-ye, or Bohea District, in the province of Fo-kien, in the dynasty of Han, A.D. 221—279. It was also discovered at different periods in several other provinces, among the hills and mountains.

Certain statistical works enumerate several provinces of the Empire where tea is produced, as far north as Tang-chao-foo, in Shan-tong, 36° 30′ N. lat.; as far south as Canton and Quong-sy, and as far east as the province of Yun-nan, but the Chinese are of opinion, that the northern provinces are not favorable to the growth of tea owing to the coldness of the climate.

There is no doubt that the tea plant is indigenous among the hills and mountains of the central provinces of China, and recent discoveries in Assam also seem to justify the assumption, that it has spontaneously extended its growth along a continuous and almost uninterrupted mountainous range, but of moderate altitude, nearly from the great river the Yang-tse-kiang to the countries flanking the south-western frontier of China, where this range falls in with, or, according to Dr. Royle, forms a continuation of the Himalayan range. But in those countries, as in every part of China, if found in the plains or in the vicinity of habitations and cultivated grounds, it may fairly be assumed that it was brought and propagated there by the agency and industry of man.

The growth of tea extends over the vast space of 28 degrees of latitude, and 30 degrees of longitude: and consequently is subject to great variations of heat and cold, and other differences of climate.

The great differences between the climates of China and India are that in the former, the rainfall is fairly general throughout the year, and the range of temperature in the hot and cold seasons much greater in the former than in the latter, where also the year can be divided into a wet and dry season.

Humboldt gives the following as the result of five years' observations at Peking made by Pére Amiot at his request:—

Mean Temperature.

Winter	...	26° 42′	...	Warmest months	...	84° 38′
Spring	...	56° 30′	...	Coldest months	...	24° 52′
Summer	...	82° 58′	...	Greatest variation	...	59° 76′
Autumn	...	54° 32′	...	Annual temperature	...	54° 90′

At Canton, which borders on the tropics, N. lat. 23° 8′, the average mean annual temperature may be stated at 71°, the mean range from 57° to 84°, and the extreme range from 29° to 94°.

This low degree of cold in a country bordering on the tropics is due to the northern winds, which for five or six months of the year come sweeping over the frozen arid steppes of Mongolia, and extend their influence throughout the China Sea to within five degrees of the equator.

At Amoy, lat. 24° 27′ 36″, which is a tea district producing teas suitable to the foreign markets, and some of very delicate flavour, the temperature seems hardly to vary from that of Canton. A register kept in 1844, gives the mean annual temperature as $69\frac{7}{10}°$: the lowest temperature marked being 49° 5′ and the highest 90°.

Although the climate of China is a strongly contrasted one, and excessive in the comparison of the heat of summer with the cold of winter, the rise and fall of temperature is progressive and gradual, and the daily variation remarkably little, seldom exceeding 8 degrees.

On the whole it is most congenial to vegetation giving a long season of repose during the dormant state of the sap ; brought about by a continued state of comparative dryness, low temperature and occasional frost, modified in its intensity and duration by position as regarding latitude : while a gradually increasing evolution of heat, accompanied by a humid state of the atmosphere succeeded by copious rains, attend the renovation of its powers, and the increasing activity of its vital energies.

The tea plant appears to be less injured by cold than benefited by heat : and flourishes best where the mean annual temperature ranges from 62° to 68° as found in China between the 27° and 33° of N. lat., where intervals of copious rain are followed by a succession of bright weather and increasing heat ; the one being necessary to the production of a rapid and luxuriant growth of leaves, and the other to fragrance and excellence of quality.

The climate found the most suitable at Java for the cultivation of tea, is that of the mountainous regions situated at 3,500 to 4,000 feet above the sea, where the temperature is 58° in the morning and 74° in the afternoon. On still higher elevations, even 5,000 and more, the tea will be highly flavoured, but in lower districts the flavour deteriorates in proportion as the situation is low.

Both Mr. Jacobson and Von Siebold agree that the tea tree requires an atmosphere of much fog and dew, which is generally found in elevated sites, and the former further observes that it requires much freshness, coolness and exposure to gentle breezes.

The green tea shrub was first discovered, and green tea first manufactured on the hill of Sunglo or Sung-lo-Shan in the province of Kiang-nan and district of Hien-ning, a town in lat. 29° 56′ N., long. 118° 15′ E. Sung-lo-Shan appears to be between 2 and 3,000 feet above the level of the plains. It is very barren, and whatever may have formerly been the case it produces very little tea now, having gone out of cultivation, and being only gathered to supply the wants of the priests of FO.

The low lands of this district and those of Mooyuen, situated a few miles further South, produce the greater part of the fine green teas of commerce. The soil here is a rich loam, free in its texture, being mixed with a considerable portion of sand. These lands, although spoken of as plains or low lands, are a considerable height above sea level.

Shanghae is the nearest place to the green tea country at which reliable climatic observations have been made, and is situated only a few feet above the level of the sea, in lat. 31° 20′ N.

The following table shows the maximum and minimum temperatures throughout the year 1844-5.

	Mean maximum.	Highest during month.	Mean minimum.	Lowest during month.
July ...	90	100	77	71
August ...	89	94	77	74
September ...	79	91	67	63
October ...	74	85	55	32
November ...	64	73	52	40
December ...	47	64	37	26
January ...	45	62	36	24
February ...	45	62	37	30
March ...	54	80	42	32
April ...	64	75	51	41
May ...	71	87	59	49
June ...	76	90	68	58

The winter of this year was exceptionally mild, the thermometer in ordinary seasons probably sinking to 10° or 12° F. As Shanghae is near the sea, the extremes of heat and cold are therefore less than in the green tea district of Hwuy-chow, and Mr. Fortune states, that eight or ten degrees allowed each way would probably be very near the truth. According to Reeves the most northern place in China at which tea is cultivated, is at Tang-Chow-Foo in 36° 30′ N. lat.

In the winter months sometimes heavy and continued falls of rain take place, at other times frost is very severe and the ground is covered with snow. In April and May the Monsoon changes from North-East to South-West, and the weather is very wet. From June to August little rain falls, but heavy dews often fall at night.

In Kintang or Silver Island, one of the islands of the Chusan Archipelago, in about 30° N. lat., the green tea shrub is cultivated very extensively, and large quantities of tea seeds were procured from here for India. The plants are growing on the hill sides, and although good tea, it is not prepared in a manner to suit the English or American markets.

As regards the temperature of Woo-e-Shan, the black tea country, it was determined from observations taken at Foo-Chow-Foo, lat. 25° 30′ N. on the one side, and Shanghae lat. 31° 20′ N. on the other. The Fokien black tea district in lat. 27° 47′ 38″ N. is situated almost exactly between these two places, but a little to the westward, and Mr. Fortune concludes that the thermometer at Woo-e-Shan would frequently rise as high as 100° F. in June, July and August, while in the winter months of November, December and January it would sink to 32° or even 28° F.

The rainfall appears to be very similar to the rainfall of the Hwuy-Chow district, *i.e.*, copious showers during the spring and early flushing period in April and May, and then little until the winter months.

Origin of Tea Culture in India.

In 1780, Colonel Kyd had some tea plants growing in his garden in Calcutta, which he had received from Canton by the captains of the East India Company vessels trading between India and China, and which although planted in a most unsuitable soil and climate, throve well. They were unfortunately not of the kind employed by the Chinese for the tea for the European market.

About the same time Warren Hastings, the Governor-General, sent some seeds of Hyson tea to Mr. George Boyle in Bhootan, to aid his idea of introducing tea into that district. But the first really practical effort to introduce tea culture into India was made by Sir Joseph Banks, who in 1788 drew up for the East India Company a series of memoirs on the methods to be adopted in the cultivation of new crops, especially tea, but probably owing to the political and commercial reasons connected with the Company's most lucrative tea trade with China, the project for the introduction ot tea was discouraged, until their monopoly was abolished in 1833. Sir Joseph's memoirs contain a scientific account of the soil, climate and districts, in which tea is cultivated in China and Japan, and also points out, that the varieties of climate necessary for the production of the various sorts of tea are not to be found in the territories of the East India Company, as they do not extend over a sufficient number of degrees of latitude. He suggests that black teas may be cultivated with success in the northern part of the province, Behar, Rungpore and Cooch-Behar, for instance, where the latitude and cooling influences of the neighbouring mountains of Bhootan, should give a climate eminently similar to the parts of China in which good black teas are at present manufactured. The mountains of Bhootan afford in a short distance, all the climates that are found in the cooler parts of the empire of China, and consequently every variety for the cultivation of green tea.

At this time Assam, Cachar and Sylhet, part of the present N.-W. Provinces, and the Punjaub, where tea is now cultivated, were not British territories, so that Sir Joseph had to confine his selection to a comparatively small slice of territory, and it is striking how accurately, as events afterwards showed, he pointed out the most suitable districts. He suggested the importation of some Chinese from Hanan, with their tea plants and tools of culture and manufacture, to the Botanic gardens of Calcutta where they might teach the art to natives, who could then be sent with a proper supply of tools and shrubs, to the places ultimately selected for the permanent establishment for the manufacture. In 1793 Sir Joseph proceeded with Lord Macartney's embassy to China, with directions to procure all possible information on the subject of tea. Some tea plants and seeds were sent to India and reared in the Botanic garden at Calcutta, but unfortunately the collections and journals of Dr. Abel, who also accompanied the expedition in the *Alceste* frigate were lost on their way home.

The troubles that ensued in India and the great continental wars in Europe afterwards, diverted the attention of the authorities, and it was not for some time that the subject was revived. Then it began to be rumoured, that the true tea plant was actually growing to a wide extent in our own than greatly increased territories, on the North-East and West of India.

In 1816 the Hon'ble Edward Gardner, Resident at the Native Court of Nepaul, found a tea tree growing in the palace garden at Khatmandu; also evidence that the plant was cultivated and manufactured in that province for use as tea. Specimens of the plant were sent to Dr. Wallich, at that time Superintendent of the Botanic Garden, Calcutta, who again forwarded them to Sir Joseph Banks, and they are still preserved in the British Museum, and no modern botanist would for a moment hesitate to pronounce them genuine tea plants.

In 1819 a Mr. Moorecroft in a journey to Cashmere, Bokhara, and Thibet, is said to have discovered that the tea plant grew abundantly at Bissahir, to the North of Gurhwahl on the banks of the Sutlej, but I cannot find this confirmed anywhere. In 1834 Lord William Bentinck, with the sanction of the Court of Directors, determined upon attempting the cultivation of tea in India. A Committee was appointed for the purpose of submitting to Government a plan for the accomplishment of this object. It was concluded that the experiment might be made with great probability of success in the lower hills and valleys of the Himalayan range; as both Dr. Royle and Dr. Wallich had independently, the former in 1827 and the latter in 1832 and 1834, recommended the same tract of the Himalayas as suitable to the purpose, the latitude, elevation, soil, climate, course of the seasons, and to a considerable extent the vegetation, being almost identical with the tea districts of China.

In March 1834 therefore, Mr. Gordon, the Secretary of the Committee, was directed to proceed to China, to procure plants, seeds, and Chinese cultivators to carry on the experiment.

Mr. Gordon left Calcutta in June 1834, reaching Macao in July. Here he was joined by a Mr. Gutslaff, with whom he visited the Ankoy Tea Hills. The plantations were mostly at the foot of, and on hills 700 feet high, and the tea plants were found forming small bushes in a sandy soil, without shade, and not irrigated. Hoar frosts were common in the district, and the ground was occasionally covered to a depth of two or three inches with snow, showing the hardiness of the plant, which was said to be capable of bearing any degree of dry cold.

Endeavours were made to reach the Bohea Tea Hills, and the green tea districts, but Mr. Gordon was recalled to Bengal, in consequence of the finding of the tea plants in the British Indian province of Assam.

Mr. Gordon, however, obtained abundance of seed of the Bohea Tea plants. These arrived in Calcutta in 1835, and the plants raised from these, were distributed to the several districts thought to offer favorable localities for the growth of the tea plant, including Madras, the Neilgherries, Coorg, Mysore and the North-Western parts of the Bengal Presidency. Mr. Bruce was also supplied with a few of the plants and manufacturers brought round from China by Mr. Gordon, for the tea nurseries to be established in Upper Assam. The experiment of the Madras Presidency almost entirely failed, with the exception of a few plants on the Neilgherry Hills and in the Nuggur country, the rest having withered away. The cause of failure however, whether owing to soil, climate or imperfect culture, is not known.

A few of the surviving plants were then planted by Captain Minchin at Mannantoddy in Wynaad, a district of the western ghauts belonging to the province of Malabar. These thrived well, becoming bushy and fine plants, which showed that some of the districts possessing the same soil and climate would be able to grow the tea plant, but whether so as to retain the same degree of astringent and stimulant property as the tea of China, had yet to be determined.

The nurseries established by Dr. Falconer from these Chinese plants, in Kumaon, Gurhwahl and Sirmore, at elevations ranging from 4,000 feet to 6,400 feet, succeeded well, and from seeds obtained from Koth, one of the nurseries, plants were raised at Saharunpore.

In 1848 Mr. Fortune was deputed by the Hon'ble the Court of Directors of the East India Company to proceed to China, for the purpose of obtaining the finest varieties of the tea plant, as well as Native manufacturers and implements for the Government Tea Plantations in the Himalayas. He arrived at Hongkong in August 1848, and proceeded North to the best tea districts.

There were various tea districts near Ningpo, where very fair green teas were prepared for Chinese use ; but these teas were not very well suited to the foreign market. Mr. Fortune therefore, determined to procure plants and seeds from the great green tea country of Hwuy-chow, a district about 200 miles inland from Ningpo or Shanghae, hitherto a sealed country to Europeans, excepting the Jesuit Missionaries and a Revd. Mr. Medhurst, who had passed through part of the district.

In October and November 1849, he procured a large supply of tea seeds and young plants from Hwuy-chow, from various parts of the province of Chikiang, Silver Island, Chusan, the districts about Ningpo, and also from the far-famed countries of Sung-lo-shan, and the black tea country of the Woo-e Hills. These were packed in a number of Ward's cases and despatched to Calcutta, and in the summer of 1850 they reached the Himalayas in good order.

The method adopted to preserve the seed in good condition for the long period between the time of plucking and that of planting them in their new home, was to sow them thickly between the tea plants in the Wardian Cases. By the time the cases reached Calcutta, the tea seeds had germinated, and the young tea plants were sprouting around as thick as they could come up.

Early in 1851 Mr. Fortune himself arrived in Calcutta with a further supply of plants and seeds, also with the Chinese manufacturers and implements. On arrival the cases were opened, and the germinated seeds repacked in other cases, by which means about twelve thousand plants were added to the Himalayan plantations. In the same year, by orders of the Indian Government, Mr. Fortune proceeded with his collection to Saharunpur, where it was handed over to Dr. Jameson, the Superintendent of the Botanical Gardens in the North-West Provinces, and of the Government tea plantations.

It is not stated on what gardens these plants and seeds were placed, but the Chinese manufacturers were taken to, and settled at the Guddowli plantation near Paorie, situated in the province of Eastern Gurhwahl in latitude 30° 8′ North, and in longitude 78° 45′ East, and ranging from 4,300 to 5,300 feet above the level of the sea.

Soon after his arrival at Saharunpur, Mr. Fortune was ordered, through the Lieutenant-Governor of the North-West Provinces, from the Governor General of India, to inspect all the tea plantations in the districts of Kumaon and Gurhwahl. In his report, he mentions that in 1847 in the Kaolagir tea plantation, situated in the centre of the flat valley of Dehra Doon, there were eight acres under cultivation, and at the time of his visit 300 acres, with 90 acres more taken in, and ready for many thousands of young plants lately raised from seeds in the plantation. At Guddowli there were about 500,000 plants, about 3,400 of which were planted in 1844, and are now in full bearing (7 years)?

The greater portion of the others were much younger, having been planted out only one, two, or three years. There were besides a large number of seedlings in beds ready for transplanting.

Mr. Fortune also visited the Hawulbaugh plantation situated on the banks of the River Kosila, about six miles north-west from Almorah, the capital of Kumaon, about 4,500 feet above the level of the sea. Some of the plants appeared to have been planted in 1844, but the majority were only from one to three years old. He states that the older plants on some of these gardens were obtained originally from the Government plantations, but where the Government obtained the seeds or plauts, and whether Chinese or indigenous is not shown.

"In the report it is noticed, that the experiments with tea in the "Kangra District were a decided success. It is ascertained that the clima- "tic condition of this region is favorable to the growth of the tea plant; "that there is much land available suited to the cultivation; that the "people generally, and the Rajpoots especially, are willing to work in the "Government plantations and factories, and that the landholders, by the "offer of rewards and by the purchase of tea leaves, may be induced to "speculate in the production of tea. There are not only well-founded "hopes of abundant markets for exported tea, either to the west as at "Cabul, or to the south as at Bombay, but there would be a brisk local "demand: the Mahomedan inhabitants of the Punjab, and specially the "Cashmeerees, who have extensively colonised in various parts of the "Province, such as Loodiana, Umritsur, Noorpoor, Jellalpoor (near "Sialkote), are all large consumers of tea. At present however, these "hill teas are highly acceptable to the European community, who "consequently outbid native purchasers.

Since the year 1848 two small plantations were established in the Kangra Valley under the care Dr. Jameson, Superintendent of the Botanical Garden at Saharunpur, and of the tea plantations in Kumaon.

At the commencement of 1852, a large undulating plain named Holta, stretching along the base of the Himalayan Range, and which had been some years previously selected by Dr. Jameson, as although naturally fertile, it had been left waste by the mountaineers, owing to a superstitious tradition, was definitely occupied and made the field for further experiments. During 1852 some 100,000 young plants were transported thither from the Kumaon Depôt. During the season of 1853, the yield was—546 lbs. 8 oz. which was sold by auction at Noorpoor in March 1854. The flavour and quality of the teas were excellent, and the teas fetched high prices—

		Rs. As. P.		Rs. As. P.	
Souchong	... ...	1 15 0	to	2 5 0	per lb.
Pouchong	... ...	1 3 0	to	1 8 0	,, ,,
Bohea	... ...	0 12 0	to	0 15 0	,, ,,

In 1835-36 forty-two thousand tea plants were raised in the Botanic Gardens Calcutta, from Chinese seeds, and forwarded to Upper Assam, Kumaon, Sirmore and the Peninsula. From the 15th June to the 1st October 1836, nine thousand plants were distributed to 170 individuals. In Jameson's Report, Botanic Garden, North-Western Provinces 1855, it is stated that: "The cultvation of the tea plant is destined ultimately to change the features of the hill provinces, and render them as valuable to the state, as those of the plains: Tea is now thriving from Kangra to Kumaon: the finer kind of tea plants, introduced by Government through Mr. Fortune from the northern district of China, *viz.*, Woo-e-san, Hwuy-Chow, Moo-yuen, Tein-tung, Silver Island, &c., have been distributed throughout the whole of the districts, and have yielded a large supply of seeds for the ensuing season.

Climate, &c., of Japan Tea Districts.

The Empire of Japan covers a space of about 15 degrees of latitude, and is placed between 30° and 45° North. Like China it is liable to extremes of temperature, but not quite so great as on the mainland.

The following table gives the maximum and minimum temperature throughout the year 1860 at Kanagawa.—(Dr. Hepburn).

1860.		Maximum.	Minimum.	Inches of Rain.
January	... ...	59	18	...
February	... ...	58	19	½
March	... ...	69	30	6½
April	... ...	76	36	3¼
May	... ...	80	44	16½
			Carried over ...	26¾

1860		Maximum.	Minimum.	Inches of rain.
			Brought forward ...	$26\frac{3}{4}$
June ...	...	87	54	$18\frac{3}{4}$
July ...	...	92	63	$8\frac{1}{4}$
August ...	...	92	69	$1\frac{1}{16}$
September ...	...	89	62	$2\frac{1}{4}$
October ...	...	84	50	$7\frac{1}{2}$
November ...	...	68	36	5
December ...	...	71	22	$3\frac{1}{2}$
				$73\frac{1}{16}$

The commencement of the rains is in the middle of May, and lasts to the middle or end of June, and this season is much more decided than in China, more resembling the raining season in Upper India amongst the Southern ranges of the Himalayas, but is shorter. The country is frequently visited by cyclones commonly known as typhoons.

The finest qualities of tea come from Ya-mu-si-ro, but tea is produced, or grows wild in all the provinces of the Island of Kin-sin, and throughout the greater part of Nipon. The tea plant is said however to have been introduced into Japan from China about the beginning of the ninth century, by a Buddhist priest named Yeitsin.

Discovery of Tea in India.

The first discovery of tea in Assam was evidently made by Mr. R. Bruce in 1823, who when visiting the then capital, Rungpore, discovered during his botanical researches, the tea plant growing on the neighbouring hills in a state of nature. To obtain a supply of these he made a written engagement with a Singpho chief with whom he had formed an acquaintance. At the breaking out of the Burmese War in 1824 Mr. C. A. Bruce, who commanded a division of Gunboats was ordered up to Sadiya. After the capital had been taken, Mr. Bruce saw the Singpho chief and spoke to him of the tea plant, when the chief produced his brother's agreement, and upon request, furnished him with several hundred plants, and a large amount of seeds. Some of these were forwarded to Mr. David Scott (at that time the Governor-General's Agent), and the remainder planted in his own garden.

In 1826 Mr. Scott sent from Manipur to Mr. G. Swinton, then Chief Secretary to the India Government, specimens of the leaves of a shrub, which he insisted was a real tea. Specimens were also forwarded to the Superintendent of the Botanic Garden at Calcutta, which were pronounced to be of the same family, but not of the same species, as the plant from which the Chinese took the leaf.

In 1832 Lord William Bentinck deputed Captain Jenkins to report upon the resources of the country. Mr. Bruce in 1833 called his attention to the fact of the tea plant being indigenous in Assam, and furnished him with an official account of the localities where the plant grew, and the different modes of preparation employed by the natives.

Captain Jenkins, in company with Lieutenant Charlton, also paid a visit to Assam, and from their discoveries were soon able to satisfy the Tea Committee, that the tea shrub was indigenous to the country, being found in Upper Assam, through an extent of country of one month's march within the Honorable Company's territories, from Sadiya and Beesa to the Chinese frontier province of Yunian, where the shrub is cultivated for the sake of its leaf. At Captain Jenkins' suggestion, the Committee recommended the Government, in the first instance, to obtain the services of one or more scientific gentlemen, who would visit Upper Assam and collect details on the spot, as preliminary information absolutely necessary, before ulterior measures could be successfully taken, with regard to the cultivation of the tea shrub of that country.

The Indian Government were fully impressed with the importance of this discovery, and entirely concurred in the views of the Tea Committee. A scientific deputation consisting of Dr. Wallich, Mr. Griffiths, and Mr. M'Clelland, was accordingly sent to Upper Assam, to report on the Botany, Geology and other details of the district.

From the geographical positions of the various tea tracts discovered, Dr. Wallich supposes, that the tea plant must have originally travelled from the frontiers of China, where a kind of tea is cultivated in the province of Yunian.

Mr. Griffiths describes the plants as being remarkably healthy and vigorous, and of all ages between quite young seedlings, and tall shrubs of twelve, sixteen to twenty feet in height, with stems mostly under an inch in diameter, and in no instance reaching beyond two inches. When seen in February, almost all the full grown plants had abundance of seed buds, and a few had still some flowers on them. The older foliage was large, and of a fine dark-green colour.

The effect of exposing the plants to sunlight and heat by removal of forest trees, was to change the leaves to a pale and somewhat yellowish green colour, which they retained for some months, and then again gradually changed to a healthy green, becoming thicker, and the plants threw out far more numerous leaves than when in the shade. It was also found that bushes that had been cut down to the ground, threw out more shoots and leaves, than those which had been allowed to remain four feet high.

In 1837 the Tea Committee reported to the Government, that the tea plant was to be found in several other parts of the Muttuck country, and it was from the young shoots of some of these tea trees, which Mr. Bruce had had cut down close to the ground together with the Jungle, that the first sample of Assam tea was made and forwarded to Calcutta.

In 1839 Mr. Bruce had discovered one hundred and twenty fresh tea tracts, some of them very extensive, both on the hills and in the plains. The hill tracts were chiefly on the Naga, Gubroo, and Tipum Hills ; the Nomsong tract on the Naga Hills, being the largest discovered up to that time.

Mr. Griffiths, in his private journals and travels in India, describes the discovery of tea in different districts. The first seen was near Kujou a village of Singphos. It occurred in deep jungle in a limited area about 300 square yards in extent, the soil was light and dryish containing a number of ravinules due, according to M'Clelland, to the effect of rain dropping from the heavy overshadowing foliage on a light soil. The tree even in its large state flourished well in complete shade, where the direct rays of the sun never penetrated, and the Singphos state that it will only thrive in the shade. Large trees were rare, but small plants were very common, although Bruce had already removed 30,000. Their leaves were all large, of a very dark green colour, and varying from 4 to 8 inches in length.

Another tea tract, "Negrigam." was discovered on the banks of a small streamlet, the Maumoo. The trees were only from 6 to 7 feet high, and the leaves were on the whole rather smaller than those of the Kujoo plants. This was probably due to the fact that the tea plants were exposed to rather more light than in the Kujoo tract.

At Nadowar, another small patch was found, in which the plants were stronger than at either of the other tracts, they were situated on a low strip of land, but rather higher than the adjoining rice land, on the borders of a jungle. The area was exceedingly limited, and the soil was remarkable for its dryness and looseness, the same as at the Kujoo and Negrigam districts.

At Rangagurrah near Tingri, it occurred in great abundance, and to a far greater extent than at any of the places previously examined. Here it was neither limited by peculiarity of soil, or such slight elevation as the place afforded, but grew indiscrimately on the higher ground, and on clumps in low raviny ground.

Large clearings of the jungle had already been made by the natives, and orders were given for a further clearing to be made. On revisiting the district ten months later, Mr. Griffiths found that all the plants, which were very abundant, had a shruby shady growth with numerous branches, and presented at first sight a favorable appearance. On closer examination, he detected a coarseness in the leaves, which had also a yellow appearance totally different to when the plants were growing in their natural shade. His conviction was that the tea would not flourish in open sunshine, at any rate unless it was gradually subjected to it, and also that cutting the main stem was detrimental, not only inducing long shoots, but most probably weakening the flavour of the leaves.

In his journey from Upper Assam to Hookhoom, Ava, and Rangoon, specimens of tea out of flower were shown him at Bamoo. The leaves were smaller and had a finer texture than any previously seen, the generality of mature leaves measuring only from four to three inches long, by two to three inches broad. Both entire and serrated leaves occurred, which had a bitter and peculiar flavour. The Khukeens make no use of the tea, and the Chinese who speak of it as jungle tea, affirm that it cannot be manufactured into a good article, and talk of the valuable sorts as being very numerous, and all as having small leaves.

Tea was also found on the Shan Hills and in Polong, but the tea is very coarse, and said not to be drinkable. Camellia Thea is also said to be cultivated in the Chittagong and Arracan Hills, and is stated to have been found in Ceylon by the Dutch, but the statement is not confirmed by any subsequent observer.

The tea tracts discovered during M'Clellands expedition were chiefly situated near the banks of rivers, on soils formed by the precipitation of the sand, when the waters' velocity was diminished sufficently to render it incapable of carrying it further, this having formed low rounded sand hills. Cuju, situated at the source of the Debroo, Tingrai on the banks of one of its tributaries, Noadwar and Cherrabarie, and Nigroo are localities of this description in which tea was discovered. It was also stated to occur at Bothath, near the foot of the Naga mountains, or close to the source of the Disang, but these tracts were not visited.

Mr. M'Clelland suggests, "that it is possible that these tea tracts may at one time have been cultivated gardens, into which the plant was introduced artificially. From the fact that in Upper Assam many artificial embankments or tumuli are found, raised to the height of 20 or 30 feet above the plain, and overgrown with ancient forest trees, as large as those midst which the colonies of wild tea plants are found ; and also referring to the antiquities of Assam, which are both extensive and decisive as to the former existence of such a state of society in regard to refinement; as would lead to conclude, that the luxuries of neighbouring countries (and the tea plant among the rest) were probably artificially introduced.

On the other hand it may be observed in favour of the indigenous nature of the plant in Upper Assam, that it is not found beyond the bounds of the alluvial basin. The plant can be traced along the course of the small rivers, which enter the valley from the South-East, in a series of distinct colonies ; rendering it probable that the seeds have been transmitted forward along the course of the currents by progressive stages through a long period of years. This is partly confirmed by the fact that on tracing the course of a river, which had grooved into the surface in which the plants were found, it was noticed that on some islets formed of sand and dry rubbish, which had accumulated around clumps of bamboos, or large trees, small tea plants began to make their appearance. The stranding of one seed or plant, would be sufficient to form the nucleus of another colony, which would gradually spread on all sides from the seed dropped from the parent bushes.

The prevailing characters of the soil on which tea was found in Assam, are lightness and porousness ; and its prevailing colour is yellow or reddish yellow, which generally becomes more developed as the depth increases up to a certain point, when it passes into sand.

Mr. M'Clelland is of opinion, that the requisite quality of the soil, which is comparatively of rare occurrence, will account for the manner in which the plant is distributed in spots or distinct colonies, instead of being uniformly diffused with the common vegetation. The component parts of the soil, he observes, consist of—

Free water	$22\frac{1}{2}$
Water of absorption	3
Vegetable matter	16
Oxide of Iron	6
Alumina	$6\frac{1}{2}$
Silex in the state of fine dusty sand, or coarse, sharp sand and dusty matter	130
	184

Mr. Piddington, who analysed and compared the tea soils of China and Assam, gives the following results :—

	The Soil of Assam.		The Soil of China.
	Surface Soil	At $2\frac{1}{2}$ feet deep.	
Water	2·45	2·00	3·00
Vegetable matter ...	1·00	·80	1·00
Carbonate of Iron ...	7·40	6·70	9·90
Alumina	3·50	5·45	9·10
Silex	85·40	84·10	76·00
	99·75	99·05	99·00
Traces of phosphate and sulphate of lime and loss	·25	·95	1·00
	100	100	100

The two peculiarities in these soils, observes Mr. Piddington, are first, that they contain no carbonate of lime, and only traces of phosphate and sulphate, and next that their iron is almost wholly in the state of carbonate of iron, a widely different compound from the simple oxides. They would be called poor yellow loams, and cotton, tobacco, or sugar cane would probably starve on them ; but we find that they suit the tea plant perfectly. It is a striking coincidence that we should find our tea soils and those of China so exactly alike.

My own analyses confirm Mr. Piddington's, as regards the absence of carbonate of lime and the presence of only traces of phosphate and sulphate in almost all tea soils, but I have not found that the iron in these soils is almost entirely in the form of carbonate, being generally present in the form of higher and lower oxides depending on the porosity of the soil and its conditions of drainage when first opened out.

The above analyses probably refer to the light porous soils full of hollows on which tea was usually discovered, and which are frequently found in Assam forests now. The presence of these hollows, which are proofs of the lightness of the soil, Mr. M'Clelland seems to attribute to the action of water collected on the foliage of the surrounding trees, and thence precipitated in heavy volumes. These soils are very often planted with tea, but they entail a great deal of expense in opening out and levelling.

In 1856 the tea plant was discovered in great abundance by Mahamed Warish, growing in the Chandkhanee hills near the boundary between Sylhet and Independent Tipperah on the banks of the River Lungy. In consequence of this discovery, further investigations were made in different districts, with the result that the tea plant was found to exist in almost the entire range of hills dividing Sylhet and Cachar, and also in the Cossiah and Jyntia Hills, which form the Northern and North-Eastern boundary of Sylhet. It is said that the probable reason tea was not discovered at an earlier date, was due to the people merely looking for the tea plant as a shrub, and not as a tree, the form in which it is usually found in its wild state. Specimens of the leaf and bush were sent to Mr. Thomson at the Botanical Gardens, Calcutta, for identification, who pronounced them to be true specimens of tea, but does not state if they were of the same variety as the plants discovered in Assam.

Mr. Griffiths based his conviction that tea cultivation would be a success in Assam on the following grounds :—

1*st.*—That the tea plant is indigenous to, and distributed extensively over large portions of Upper Assam.

2*nd.*—That there is a similarity in configuration between the valley of Assam, and two of the best known tea provinces of China.

3*rd.*—That there is a similarity between the climates of the two countries, both with regard to temperature and humidity.

4*th.*—That there is a precise similarity between the stations of the tea plant in Upper Assam, and its stations in those parts of the provinces Kiang-nau and Kiang-see, that have been traversed by Europeans.

5th.—That there is a similarity, both in the associated and the general vegetation of both Assam and those parts of the Chinese tea provinces, situated in or about the same latitude.

Physiological Botany.

Before describing the tea plant, it will be advisable to treat briefly of the structure, method of growth and function of the various parts of plants generally :—

When a seed is placed under favourable circumstances, the embryo it contains begins to develop, the lower part of its axis called the "radicle" or root growing in a downward direction, while the upper part elongates upwards, carrying the plumule or stem with it, while at the same time the cotyledonary portion becomes developed and forms the first leafy organs. Upon the ascending axis or stem all the future organs of the plant are arranged, those that immediately succeed the cotyledons constituting the first true leaves of the plant ; and all which succeed the leaves in the order of development, such as the flower and its parts, are merely modifications, designed for special purposes, of those organs which have preceded them.

The three organs—the stem, root, and leaves, are those of nutrition or vegetation, while the flower and its parts form the organs of reproduction.

The stem or ascending axis in the embryo stage consists entirely of parenchymatous cells, but as soon as growth commences, some of these cells become developed into elongated vessels and wood cells, so as to form vascular bundles, which are characteristic of dicotyledonous stems. As growth proceeds these vessels enlarge and form new ones from the parenchymatous cells between them, until at the end of the first year's growth they form a zone of wood round the central mass of parenchyma or pith, interrupted at intervals by radiating lines called "medullary rays," which connect an external layer of parenchymatous tissue, or "bark" with the pith.

On the outside of the wood is the "cambium" or growing layer, from which new cells are developed annually with the formation of new wood on the outside of that of the first year, while at the same time a new fibrous layer is added to the inside of the bark. Each successive year's growth is a repetition of that of the first year, except as regards the pith, which does not increase in size after the first year, so that in all such plants there are but four separate parts, namely, pith, wood, medullary rays, and bark.

The "cambium" consists of a layer of vitally active cells, which is dormant during the winter or cold weather, but is in full activity in the spring, when it becomes charged with the materials necessary for the development of new structures.

The presence of leaves and leaf buds is the essential characteristic, by which a stem may be distinguished from a root. Leaves are always developed at regular points upon the surface of the stem, which are called "nodes." Under ordinary circumstances one or more buds are developed in the axil of every leaf, and in the same manner, the apex of a stem as well as all its divisions which are capable of further elongation, are also terminated by a similar bud. Each bud is produced by an elongation of the parenchymatous system of the stem or its divisions, and consists at first of a minute conical parenchymatous mass, which is connected with the pith; around this other vessels and wood cells are soon developed, also in connection with similar parts of the wood, and on the outside of these is the bark, from which little conical cellular projections are developed, being the rudimentary leaves. As growth proceeds these parts become more evident, and a little conical body is ultimately produced at the apex of the stem, or laterally in the axil of leaves, and the formation of the bud is completed. In the buds of tropical regions, which are not exposed to the influence of winter, any protective organs or scales, which are formed on plants growing in temperate climate, are absent as they would be practically useless.

The bud contains all the elements of a stem or branch, and is really the first stage in the development of these parts, the axis being here so short, that the rudimentary leaves are closely packed together and thus overlap each other. When growth commences in the spring or whenever vegetation is re-animated, the internodes or spaces between the leaves become developed, and these therefore become separated from each other, and thus the stem increases in length or a branch is formed. In other words, the leaves, which in a bud state overlap each other and surround a growing point or axis, by the elongation of the internodes of that axis become separated and dispersed over a branch or an elongation of the stem, much in the same way as the joints of a telescope become separated from each other by lengths of tube, when it is drawn out. The branch therefore, like the bud from which it is formed, necessarily contains the same parts as the axis upon which it is placed, and these parts are also continuous with that axis, with the exception of the pith, which, although originally continuous in the bud state, ultimately becomes separated by the development of tissue at the point where the branch springs from the axis.

In the same way as branches are produced from buds placed on the primary axis or stem, so in like manner from the axils of the leaves of these branches other buds and branches are formed, the smaller divisions being commonly termed "twigs."

If all the buds were to develop regularly the branches and twigs would have a certain symmetry, but this is usually destroyed by the non-development of some of the buds, due to local or special causes, as want of light, too much overcrowding, or bad soil, &c., in which case the buds become abortive and present the appearance to which the term "bangy" is commonly applied among planters.

The root or descending axis in its first development takes an opposite direction to the stem, avoiding the light and air, and fixes the plant in the soil in which it grows.

The true root is formed at first by additions made within the extremity of the radicle or embryo. Growth commences by the multiplication of cells by division, just within the apex of the radicle; these cells then elongate by their own inherent vitality, by which the tissue constituting the apex is pushed onwards and gradually perishes, or is thrown off; the innermost of these newly formed cells then remain unaltered, while others immediately within the point of the root continue to multiply by division, and grow in a similar manner to the former, by which the layer of tissue at the apex is again pushed forward and perishes in like manner as before; then new growth commences as in the former instance, to be followed by similar changes.

Roots do not grow, therefore, throughout their entire length like stems, but only within their extremities, which are continually pushed forward and renewed. Thus the apex of the root is always clothed by a layer of denser tissue than that which is within it, and which forms a sort of protecting shield to the young extremity of the root.

Roots increase in diameter by the formation of annual layers of wood in the same manner as stems.

At first the elongating growing extremities of the root consist entirely of parenchymatous cells : wood cells and vessels, however, soon make their appearance, and are constantly added to below, by the new tissue formed as the root continues to lengthen. When the root is fully developed, these vessels and wood cells generally form a central mass of wood, in which there is commonly no pith ; externally there is a true bark, which is also covered when young by a modified epidermis or skin, furnished with hair like prolongations called "fibrils," which are specially evident upon young growing roots, and as these advance in age they perish, while the tissue, from which they were developed, becomes harder and firmer and is converted gradually into bark. Roots have no leaves and normally no buds, hence they have no provision for regular ramification as in the case of branches ; but they appear to divide and sub-divide according to circumstances without any definite order, hence while the branches of the stem have a more or less symmetrical arrangement, those of the root are unsymmetrical.

The true or primary root, from its being formed by a direct elongation of the radicle, generally continues to grow downward for some time at least, forming a main trunk or axis, from which the lateral branches are given off ; such a root is termed a tap root and is generally found in dicotyledonous plants. These tap roots do not however, commonly descend far into the ground, but their branches become much developed laterally, in some cases even more so that those of the stem.

The leaf is a lateral development of the parenchyma of the circumference of the stem or branch, containing in most higher plants a frame work or skeleton, consisting of wood cells and vessels, all of which structures are in direct connection with similar parts of the same system in the stem.

The terms upper and lower are applied to the two surfaces of ordinary leaves, because they are usually placed horizontally, so that one surface is turned upwards and one downwards.

Leaves generally fall after lasting one season, when they are termed deciduous or annual, or remain until the formation of new ones, so that the stem is never without leaves, when they are termed persistent, evergreen or perennial, and it is of the latter we have now to treat.

The whole of the leaf is clothed by the epidermis, which is commonly furnished with "stomata" or orifices opening into the intercellular cavities beneath, so as to allow a free communication between the internal tissues and the external air, and are hence often called breathing pores. They are surrounded by cells of a different form from those of the epidermis, and they also usually contain some chlorophyll granules. These bordering cells have the power of opening or closing the orifice which they surround, according to circumstances, and are commonly called "guard cells." The stomata are usually on the underside of the leaf, except in the case of certain water plants whose leaves float on the surface, when they are above, also in certain cases where the leaves hang in a manner to present neither an upper or lower surface, when the stomata may appear on either side. The epidermis is also furnished with various appendages as hairs, &c., which are well seen in the case of tea, especially on the younger leaves and shoots, on which they form a kind of protective covering.

The fibro-vascular system, or veins of the leaf are in direct connexion with that of the stem or branch, and is usually double, that is, it consists of an upper layer, which is in connexion with the fibro-vascular system of the wood, and of a lower which is continuous with the "liber" or inner bark.

The parenchymatous tissue, which is situated between the epidermis of the upper and lower surfaces of the leaf and which surrounds the veins, varies in amount in different leaves ; in ordinary leaves it is only moderately developed, while in other leaves it is formed in large quantities, when they become thick and fleshy and are termed "succulent." In ordinary flat leaves, all the cells composing the parenchyma are commonly green from containing chlorophyll, but in succulent leaves the cells in the centre of the parenchyma are usually colourless, as is the case with tea.

While the cells of the epidermis are compact and have no interval, those formed by the imperfect contact of such cells, except where stomata occur, the form and arrangement of the internal cells are entirely different, being loosely connected and having numerous large spaces between them, which are connected with the stomata, and thus a free communication is kept up between the interior of the leaf and the external air, which is essential for the due performance of its functions.

The Flower and its Appendages.

These are called the reproductive organs, because they reproduce the plant by the production of seed. The parts of a flower are only leaves in a modified condition adapted for special purposes, hence a flower bud is analogous to a leaf bud, and the flower itself to a branch the internodes of which are but slightly developed, so that all its parts are situated in nearly the same plane.

The outmost envelope of the flower called the "calyx" is composed of five or seven leafy organs called "sepals" which are usually green like true leaves.

The second or inner envelope is called the "corolla," and consists of five, six or nine petals, which are white in colour and of a more delicate structure than the sepals. The corolla is also the part of the flower, which contains the odoriferous properties, which are sometimes so strongly developed.

It is unnecessary here to enter into the structure of these parts of the flower, and it will be sufficient to state that the two envelopes form a kind of protection to the essential organs of reproduction, which are termed botanically "the andrœcium and gynœcium," the action of both being necessary for the production of perfect seed.

The andrœcium or male system of flowering plants, is the whorl or ring of organs between the corolla on the outside, and the gynœcium or female system on the inside. It is composed of a number of organs, called "stamens," each stamen consisting generally of a thread-like stalk, called the "filament," surmounted by the little bag or case, called the "anther," which contains a powdery matter termed the "pollen." The only essential part of the stamen is the anther with its contained pollen, for when the latter is absent, the stamen cannot perform its special functions and is termed abortive or sterile, in other cases it is termed fertile. In the tea flower, the stamens are numerous and the anthers are two celled. When the anthers are perfectly ripe, they open and discharge the contained pollen generally at the period when the flower is fully expanded, and the pistil consequently sufficiently developed to receive the influence of the pollen ; at other times, however, the anthers burst before the flower opens, and while the pistil is still in an imperfect state.

The matter contained within the pollen cells is called the "fovilla." It is a semi-fluid granular protoplasm in which are suspended very small starch granules, and what appears to be oil globules. As the pollen cell approaches to maturity, the fovilla becomes more concentrated, and contains less fluid matter and more granules. The fovilla is the essential part of the pollen cell.

When the pollen is thrown upon the stigma, the pollen cell gradually protrudes by a true growth a delicate tube, filled with the fovilla and called the "pollen tube;" this penetrates through the tissues of the stigma and style to the placenta and ovules, now to be described.

The gynœcium, pistil, or female system of the flower, occupies the centre of the flower, the anthers and floral envelopes being arranged round it.

The pistil consists of one or more modified leaves called carpels, signifying the fruit, because the pistil forms the essential part of that organ.

Each carpel consists, first, of a hollow inferior part arising from the "thalamus" or stem, called the "ovary," containing in its interior one or more little round or oval bodies, called "ovules," which ultimately become the seeds, and which are attached to a projection on the walls termed the "placenta;" second, of a stigma composed of lax cellular tissue without epidermis, elevated in the case of tea on a stalk prolonged from the ovary, called the style; this is traversed by a very narrow canal, which communicates below with the cavity of the ovary, and above with the stigma. It is through this canal that the pollen tube penetrates to the ovules.

The fruit of tea is many celled and consists of two or more ovaries completely joined together, forming a spheroidal body more or less regular. The outer surface is usually smooth but marked with furrows showing the point of union of the constituent ovaries, and is termed, two or three lobed, according to the number visible.

The ovules are attached internally to the placentas developed from the margins of the individual carpels or ovaries, and with which the stigma is directly connected. After the process of fertilization has been effected, important changes take place in the pistil and surrounding organs of the flower, resulting in the formation of fruit, which consists essentially of the mature ovaries, containing the impregnated ovules, which are then termed seeds.

The fruit when perfectly formed consists of two parts—the shell or pericarp, and the seed or seeds contained within it. In the case of tea, the pericarp before the ripening of the seed is hard in texture and green in colour, but when ripe it assumes a dark brown colour.

The seed consists essentially of two parts, namely, of a kernel and integuments.

There are two seed coats or integuments, known as the testa, or outer, and segmen or inner coat. The former is brown in colour, membranous or almost woody, the latter lighter and more delicate. The kernel of the seed corresponds to the same portion of the ovule in a mature condition, and has undergone the following changes after the process of impregnation has been effected.

At an early period a quantity of protoplasmic matter of a semi-fluid nature is deposited in the embryo-sac. In this matter nuclei soon make their appearance, and their formation is succeeded by the development of a number of loose cells; these are first produced from the walls of the embryo-sac, and their formation extends gradually inwards. A similar development of cells also frequently takes place on the outside of the embryo-sac, and therefore in the nucleus itself, which is in such cases necessarily thickened. These cells which contain nutritive matters of various kinds are especially designed for the nourishment of the embryo, which is developed in the sac after the process of fertilization.

The embryo, by absorbing the nourishment by which it is surrounded, begins to enlarge, and in so doing presses upon the parenchymatous cells by which it is enclosed, and thus causes their absorption to a greater or less extent according to the size to which it ultimately attains. To the tissue which remains and forms a solid mass round the embryo the name of albumen has been given, but as the nature of this substance varies from vegetable albumen it is called the "perisperm."

The cells of the perisperm of tea contains a large amount of oily and other matter and act as reservoirs of nutriment for the use of the embryo, during the process of germination.

The embryo is the rudimentary plant and is present in all seeds: it contains within it, in an undeveloped state, all the essential parts of which a plant is ultimately composed. It consists of three distinct parts, *viz.*, the radicle, plumule and one or more cotyledons (expanded lobed bodies).

In tea seed the two large oily lobes are the cotyledons, and when separated, the plumule and radicle can be easily distinguished especially during the process of germination.

It will be necessary here to state the method of the formation of new cells, before treating fully the functions of different parts of the plant. All plants in their earliest conditions are composed of one or more cells, hence all the organs which afterwards appear, must be produced by the modification of such cells, or by the formation of new ones.

Cells can only be formed from the thickened fluid called protoplasm, which is contained in their interior, or has been elaborated by their agency: the cell wall or membrane of cellulose taking no part in the formation of cells.

Cells originate in one of two ways, either free in the cavities of older cells, or by the division of such cells, the latter being the usual mode of growth in the nutritive organs of vegetables.

In flowering plants free cell formation only occurs in the embryo-sac, in which part after impregnation, both the germinal vesicles and cells of the albumen originate in this way. It occurs in one of two ways, either from a nucleus, or without the previous formation of a nucleus; in the first case, a portion of the protoplasm collects into a more or less rounded form, with a defined outer border, thus forming the nucleus of the cell; upon this a layer of protoplasm is deposited, which assumes the form of a membrane and expands so as to form a vesicle; on the outside of this a cellulose membrane is secreted, and the formation of the cell is completed. The protoplasmic vesicle in this case forms the subsequent lining of the young cells, and although its existence is in most cases but transitory, it is a permanent formation in cells containing the green colouring matter of plants (chlorophyll), as in cells of leaves.

In the second case, *i.e.*, without a nucleus, the new cell is formed by a portion of the parent protoplasmic vesicle separating itself from the rest of the protoplasm, assuming an oval form, and secreting a cellulose membrane on its surface, so as to form a new cell, lying free in the cavity of the parent one.

Cell division also takes place in two ways—*first*, without absorption of the walls of the parent cell; and *second*, with absorption of the walls of the parent cell, and the setting free of the new cells.

In the first process, which is the one by which all vegetating or growing parts of plants are produced and increased, the protoplasmic lining of the cell, which must be in perfect condition, becomes gradually constricted on all sides, folding inwards in a sort of hourglass contraction and ultimately coalescing, and so dividing the original protoplasmic lining and contained protoplasm into two distinct portions ; each portion then secretes a layer of cellulose over its whole surface. The original cell thus becomes divided into two, and forms two cells, each of which has the power of growing until it reaches the original size of the parent, and then either or both may again divide and the newly formed cells grow in a similar manner to the size of their parent.

The second process of cell division takes place in the formation of pollen cells, and only occurs in connection with the organs of reproduction ; the process is as follows :—In certain parent cells, the protoplasmic lining becomes infolded so as to divide the protoplasm into four portions, either directly or indirectly by first dividing it into two, and then each of these being again divided into two others. The whole of the protoplasmic contents of each of these four cells then secretes a layer of membrane on its outside, and thus four perfect cells are formed in the cavity of their parent. As these continue to enlarge, the walls of the parent cells become ruptured or dissolved, and the cells being thus set free the process is completed.

By the ordinary method of cell division cells are in many instances produced with enormous rapidity, as is well seen in the rapid growth of many plants, but this is partly due also to the expansion of cells already formed. The cell wall of all young and vitally active cells is porous and readily imbibes fluids, so that liquid matters are constantly being absorbed and transmitted through such cells, by a process called "osmosis." This physical force is a most important agent in plant life, for by its agency plants are enabled to absorb crude food by their roots in a fluid state, and transfer it upwards from cell to cell to the leaves and other external organs, for the purpose of being elaborated by the action of light and air. It is, moreover, by the analogous process of diffusion of gases, that the cells on the surface of plants are enabled to absorb and transmit gaseous matters.

This absorption and transmission of liquids through cell walls is easily explained by the fact, that when two liquids of different densities are separated by a membrane, they diffuse into one another until the density of both is equal, the thinner fluid passing through more rapidly than the denser one. The same way in plants, for as the fluid contents of the cells of the roots are denser than the water contained in the media in which they grow, they will continually absorb the latter ; and as the changes, which are going on in the cells by evaporation, assimilation, and other processes on the surface of plants tend to thicken their contained liquids, there will also be a constant passage of the absorbed fluids from cell to cell, towards those parts where such processes are taking place. The laws of ordinary capillary attraction and of the diffusion of fluids also regulate the flow of the juices, which in certain cases may be set in motion by either force. The action, however, of the intervening cell wall in greatly modifying or even overcoming osmotic action is evidenced, by the numerous cases in which neighbouring cells contain different substances without their intermixture. All cells exposed to light and air which contain a protoplasmic lining, have the power of producing in their contents the various nitrogenous and non-nitrogenous compounds, which are concerned in the development of new tissues, and in the formation of the various secretions of the plant. In old cells, the secretions of the cells are also in part deposited, which has an important influence in checking the necessary osmotic action.

The function of the vessels and vascular tissue of young plants is chiefly to act as sap-carriers, but old vessels are found only to contain air ; and it is also supposed that the elongated cells, which by their construction and mode of combination form a tissue for giving strength and support to plants in their young state, before filled with secondary products, form the chief agents by which the fluids absorbed by the roots are carried upwards to the leaves and other external organs, to be elaborated by the agency of light and air. The down current of elaborated sap is generally believed to pass through the cells of the inner bark.

The epidermis or outer covering of leaves, &c., has the special functions of protecting the tissues beneath from injury and from being too rapidly affected by atmospheric changes ; of regulating the transpiration of watery fluids and of absorbing and exhaling gaseous matters, and probably to some extent water. For these purposes it is modified in plants growing in different climates, in hot and dry climates being composed of two or more layers of thick cells to prevent too rapid an exhalation of moisture.

The stomata or breathing pores already mentioned, which are situated in the epidermis chiefly on the underside of the leaf, have the special function of facilitating and regulating the passage of fluid and gaseous matters, so that the more there are present in a given area, the greater will be the exhalation. Their method of action has been noticed to be as follows :—" When plants are freely supplied with moisture, the stomata have their bordering guard cells distended with fluid, elongated and curved, so that the orifices between them are open: whilst when there is a deficiency of fluid, the bordering cells contract, straighten on their inner surfaces, and thus close the orifices, preventing exhalation to a more or less degree.

The object of hairs on plants appears to be to protect the epidermis and parts beneath from injury from cold and other external influences; they are usually most observable on the young shoots, and disappear to a great extent as the shoots and leaves get older.

The function of the intercellular canals of the leaf, which are in connection with the stomata, is, except in the spring when filled with sap, to allow a communication between the external air and the contents of the internal tissues, governed by the laws regulating the diffusion of gases.

The functions performed by the root are :—

> To fix the plant firmly in the earth; to absorb liquid food, and to excrete into the soil certain matters, which are injurious or unnecessary for the healthy development of the plant. Certain roots also have the power of secreting a peculiar acid substance, which has a solvent action on the mineral matter of the soil required by the plant as food.

The absorption of nutriment for the use of the plant from the soil, is almost exclusively confined to the cells and fibrils of the newly developed portions and young parts near them. Hence in the process of transplanting, it is necessary to preserve the young growing roots as far as possible or the plants are liable to die. The injury done to plants in transplanting is also to a great extent influenced by atmospheric circumstances and conditions of the soil at the time, in which such operation is performed: thus, under the favorable circumstances of a warm soil and moist atmosphere, the destruction of a large portion of the young extremities of the root will do, but little injury, as the plant will then quickly form new absorbent extremities; but if the conditions of the earth and soil be the reverse, a large destruction of the young extremities of the roots will cause the plant to die before new absorbent extremities can be formed. Special attention should be paid to these points when transplanting in the growing season, but it is better, when possible, to transplant when the growing season is drawing to a close, or before it re-commences, as at such periods little or no absorption takes place, and the plants have time to recover themselves, before they are required to perform any active functions.

The absorption of food by the youngest rootlets is due to osmosis between the contents of their cells, and the fluids of the surrounding soil. As the roots grow in length by additions near their extremities, and as it is at these parts that absorption of food almost entirely takes place, they are always in the most favourable circumstances for obtaining it, because in their growth they are constantly entering new soil as one portion becomes exhausted. When the root meets with a store of nourishment in the soil, a greatly increased development of rootlets and fibrils takes place for its absorption. Roots can only absorb substances in a liquid state, therefore the different inorganic substances, which are derived from the soil, and which form an essential part of the food of plants, must be previously dissolved in water.

Plants possess the power, to a certain extent, of selecting food by their roots, some taking in their growth one ingredient more freely than others, so that the ashes of different plants show marked differences in their composition: hence arose one of the chief reasons for growing a rotation of crops, in which plants of different selective powers are grown alternately, in order that the soil may not so soon become exhausted of any one constituent.

They cannot however prevent the absorption of any poisonous ingredient there may be in the soil, and when this is taken up, the plant is either checked in its growth, or if the ingredient be present in large quantity and in a soluble condition, completely killed. The excretion of certain matters by the roots of plants into the soil when grown for a number of years in succession is important, as it sometimes totally prevents their further growth, and makes a rotation of crops necessary.

It is not known whether tea has this property, but if it has, it would partly account for the gradual decay and dying out of old plants, as the soil in their neighbourhood became unfit for their growth.

The functions of the stem are to form a support for the leaves and branches, and thus enable them to be freely exposed to the influences of light and air, which are essential for the proper performance of their functions and development; to convey air and fluids to and from the leaves and other organs of the plant, and to act as a reservoir for the secretions of the plant.

The wood, when young and pervious, is the main agent by which the crude sap is conveyed upwards to the external organs or leaves, there to be elaborated with the formation of various organic products necessary for the further development of the plant. As the wood increases in age, substances are deposited on the tissues, which harden and strengthen them at the same time rendering them useless as carriers of sap. It is for this reason that comparatively young straight wood, free from knots, &c., is required to allow a free passage of sap and so enable a rapid and healthy growth.

The materials from which new wood is formed are elaborated in the leaves, so that without leaves it cannot be formed, and the more leaves there are on a plant, the thicker will be the wood. A plant however that has been cut down and all the leaves removed during the quiescent period, can send out shoots owing to the elaborated sap that has been stored up in the roots and lower part of the stem, and the new leaves thus formed assist in the formation of new wood.

The essential functions of leaves are as follows :—The evaporation of excess of moisture from the sap, the absorption, decomposition and exhalation of gases, and the formation of the various organic products of the plant. These functions are performed with the agency of air and light.

The effect of the evaporation of moisture is to concentrate the sap in the leaves and growing shoots, and cause the ascent of a further supply of sap from the roots. It takes place through the stomata already mentioned, and the quantity evaporated is proportional to the number of these present ; excess of moisture in the atmosphere reduces the amount evaporated to a considerable degree, consequently the sap remains in a more diluted condition.

The gases that are absorbed and given out by the leaves are almost entirely carbonic acid and oxygen, and it is from the decomposition of the former in the chlorophyll containing cells of the leaf, that plants derive almost their whole supply of carbon, which forms about 50 per cent. of the organic matter of the plant. This absorption of carbonic acid only goes on in the day, being greatest when the plant is exposed to direct sunlight ; and with the decomposition of the carbonic acid, oxygen gas is evolved and continually exhaled into the air. Oxygen is also absorbed during the whole period of growth, and after oxidising part of the carbon of this plant is evolved again as carbonic acid.

These two processes are quite distinct, the former taking place to the greatest extent as evidenced by the continual gain of carbon to the growing plant. By the alterations produced in the watery contents of the green leaves by exposure to air and light, the matters which they contain undergo certain chemical changes with the formation of various organic substances, which constitute the mature plant. For these changes to take place in a thorough manner, it is necessary that the conditions of climate should be favorable and that time should be allowed ; otherwise certain constituents would be immature, while others would hardly be formed at all. In the case of tea this is a most important consideration as it it is well known, that leaf which has been grown very rapidly yields a weak sap of inferior quality, especially when the plants on which it is grown have had all, or nearly all their leaves removed by pruning, so that there is little or no place in which the necessary chemical changes can go on.

The Tea Plant and its varieties.

The tea plant belongs to the genus "Thea" and to the natural order ternstrœmiaceœ, and is so very closely allied to the genus camellia, that it was disputed by botanists whether they were not absolutely one genus instead of two genera, as Linnœus asserted, and botanists have had difficulty in distinguishing between, and identifying plants of the Thea and of the Camellia genus.

There are now three recognised varieties of the tea plant—Thea Bohea, Thea Viridis (Sinensis), and Thea Viridis Assamica, the two former being natives of China, and the latter of Assam.

In a comparison of the specific characters of the Thea Viridis of China and Thea Assamica, Mr. Masters endeavours to prove that they are identical or very nearly so, and he states "that the only difference existing between the Assam plant and the China Bohea plant is found in the texture of the leaf. The Assam leaf is long, thin, membranous, often undulated ; whilst the China leaf is short, thick, coriaceous and generally straight ; and although in the general appearence and habits of the two plants there is a marked difference, yet the seeds which were sent from China as those of the true tea have produced plants, differing more from each other, than the generality of them do from the Assam plant."

Dr. W. Jameson, Superintendent of the Botanical Gardens, North-West Provinces, in his report to the Indian Government, 1847, says :—

" In the plantations there are two species (varieties ?) and two well marked varieties. The first species is characterised by the leaves being of a pale-green colour, thin, almost membranous, broad lanceolate, sinatures or edge irregular and reversed, length from three to six inches. The stem of newly formed shoots is of a pale reddish colour, and green towards the end. The plant is also marked by its strong growth, its erect stem, and the shoots being generally upright and stiff. The flowers are but small and it seeds but sparingly.

The second species is characterised by its leaves being much smaller, and not so broadly lanceolate ; slightly waived, of a dark green colour, thick and coriaceous ; sinature or edge irregular, length from one to three and a half inches. In its growth it is much smaller than the former, and throws out numerous spreading branches, and seldom presents its marked leading stem. This species agrees well with the characters assigned to the Thea Bohea brought from Amoy in China by Mr. Gordon, and forms nearly the whole of the plantations of Kumaon and Gurhwal.

There is however an extremely large variety of tea plants, both in China where from its growth under varying conditions of soil and climate for centuries, it is to be expected that new varieties would arise, and in India where the Chinese plants introduced by Messrs. Gordon and Fortune have intercrossed with the indigenous bushes of Assam, and the hybrids thus formed with each other, and with the original China and indigenous bushes."

The two varieties mentioned by Dr. Jameson are probably the same as those described by Mr. Fortune, who introduced them from China :—

He remarks—that two tea-plants, considered to be distinct varieties, are met with in China, both of which have been imported into Europe. One the Canton variety, is called Thea Bohea : the other, the Northern variety called Thea Viridis. The former produces inferior green and black teas, and the latter the fine green teas in the Great Hwuy-Chow country, and the finest black teas of the Bohea Hills, the latter being formerly supposed to be produced from the "Thea Bohea."

The variety "Thea Viridis" differs considerably from "Thea Bohea," but only very slight differences can be detected in the Thea Viridis of the green and black tea producing districts, the latter having rather less tendency to throw out branches than the former, and its leaves were sometimes rather darker and more finely serrated.

These slight differences are probably due to the fact that the tea plant is multiplied by seed, and the seed raised year after year in a somewhat different climate to the original one, and it is possible that the greater differences of Thea Bohea are due to the same cause, and all the tea in China was derived from one species and one variety only.

The following description of the tea plant is given in Robinson's, "Assam :"

"The ordinary height of the shrub is from 5 to 8 feet, though it occasionally attains a far greater size It is a polyandrous plant of the natural order ternstrœmiaceæ. The flowers which, open early in spring, appear upon the plant about a month, are smaller in size, and much less elegant than those which render some species of the camellia so attractive. They are about an inch in diameter, slightly odorous, and of a pure white colour ; they proceed from the axils of the branches, and stand on short foot stalks, at the most two or three together, but usually solitary. There are five or six imbricate sepals or leaves supporting the blossom, which fall off after the flower has expanded and leave from six to nine petals surrounding a great number of yellow stamens, that are joined together in such a manner at their bases, as to form a sort of floral coronal. The seeds are enclosed in a smooth hard capsule, of a flattish triangular shape, which is interiorly divided into two, three, and even five cells, each containing a firm white and somewhat oily nut about the size of a hazel nut, of a bitterish and nauseous taste. They ripen in December and January, the stem is generally bushy with numerous branches bearing a very dense foliage, and in its general appearance is not unlike a myrtle, though not so symmetrical as that plant. The wood is light coloured, close grained, of great comparative density, and when freshly cut or pealed, gives off a strong smell like that of the black currant bush. The leaves are alternate, on short thick channelled foot stalks, coriaceous or leathery, but smooth and shining, of a dark green colour, and a longish elliptic form, with a blunt notched point, and serrated except at the base. The leaves are a good deal affected by the site in which the plant is grown, whether under the thick umbrage of large trees, or in open spots exposed to the influence of the sun's rays, as well as by the nature of the soil in which the plant is found. The tea shrub may be described as a very hardy evergreen, growing readily in the open air, from the equator to the 45th degree of latitude

Origin or Hybrids.

These originated from the indigenous Assam tea being crossed with the China plant introduced into India by Mr. Gordon and Mr. Fortune.

There appears to be no record that the hybridization was carried out intentionally by any person, but seems to have been merely the result of the plants being introduced into the neighbourhood of each other.

It is a question whether it was really a true hybridization, or the coalescing of two varieties, which in the course of ages and by the influence of circumstances had become quite distinct, originating a third variety superior to all. Mr. Baildon's theory is that the tea plant is really indigenous to India, and that from India it was introduced to China and Japan about 1,200 years ago. Legendary lore seems to support Mr. Baildon's theory, that there is only one species of tea, the Indian, and that the inferior growth and smaller leaves of the China tea are the result of the plant travelling far from home into an uncongenial climate, and unfavorable conditions of soil and treatment.

There is no doubt that plants raised from hybrid seed grown in the plains and planted in the hills, where the climate is cooler and less forcing, diminish in size of leaf and also in outturn, and if they were planted on poor soil they would deteriorate still more, and it is possible that Mr. Baildon's theory is correct.

As regards the question of whether the indigenous bushes discovered in Assam and elsewhere in India, are all of one variety little seems to be known.

Planters distinguish between the indigenous bushes of different districts, stating that some are more delicate than others, for example, the Rajah of Manipuri's indigenous is said to be best in all respects, at least for certain districts, followed by Bazaloni, Talcock, Chadua, Singlo, and Tingri, which are more delicate for the first three years of their growth.

It is evident from Mr. M'Clelland's discovery of the method by which the tea plant spread through Upper Assam, that the plants in the various tea tracts situated near the banks of rivers originally sprang from one source, and any modification in their appearance or character must be due to the varying conditions of soil and exposure to which they were subjected. It was generally observed that the bushes occurring in dense jungle and forest, where no ray of sunlight could penetrate, had darker colored and larger leaves, than those more exposed to light.

The result of crossing these indigenous plants with the China bushes, obtained from situations varying considerably both in soil and climate, has resulted in several varieties of hybrids, many of which are great improvements of the parent stocks, but still there are many, which are little better than the original China bushes.

These hybrid varieties are as yet merely distinguished by the names of gardens on which they are grown. Planters also speak of them as being a good jât of hybrid or bad low jât, according to whether indigenous or China qualities and appearances predominate.

There is a gradual process of selection going on, and has been going on for some years. Planters buy their seed for new plantations from gardens, which have made a name either for the amount of outturn or quality and high price of the tea produced. The bushes from which the seed is obtained, are the same as the bulk of those forming the garden, but as a rule either in the same or adjoining gardens other varieties of bushes occur, inferior to those from which the tea is produced, and these may by natural causes fertilize the flowers of the better jât, with the result that the product would be inferior in certain respects to the parent stock.

The great differences in soil, climate, altitude and latitude, &c., of the different tea districts of India and Ceylon, require that the plants should have certain characteristics suitable to the conditions under which they are to be grown, for example, plants grown at high elevations would require to be hardier, than plants grown in the damp steamy plains of Assam.

It will probably be impossible to combine by hybridization the delicate flavour of the hill teas, with the coarse rank strength obtained in the bheel gardens and plains of Cachar and Assam, as the flavour seems to be due to the slower growth and consequently better development of certain constituents of the leaf; but the strength of the hill teas, without much deterioration of flavour, might possibly be obtained by judicious adoption of this process.

It is stated, that although Java does not present the necessary qualifications for tea cultivation to such an extent as does Assam, it has proved a decided success. This success appears to have been obtained by annual importations of excellent seed, and by procuring the best cultivators.

Good China stock should have been imported (owing to the greater certainty of success) solely for the purpose of experimenting in crossing, that is, by applying the fertilising power or pollen of one, to the stigmata or communicating organs of fecundation of another ; and, as according to the law that the produce of such fecundation possesses the properties of the plant furnishing the pollen, it is obvious that the pollen of the Chinese plants must be applied to the stigmata of those of Assam. By repeating the experiments indefinitely, always applying good pollen from Chinese plants to the plants produced by previous crosses, it may be expected that the indigenous plant of Assam will lose most or all of those bad qualities that may, with reason, be supposed to exist in it.

It is a fact that wild stocks are more or less irreclaimable, and it appears that tea possesses this bad quality in a considerable degree. All the Chinese, or rather Shan-Chinese, agree in saying that the wild plant was not considered worthy of being submitted to cultivation ; and the tea of the Pollong District of Burmah, which is said to be from the wild stock, has not, hitherto, although cultivated to a certain degree from a remote period, undergone any improvement.

THE FORMATION OF SOILS; AND THEIR CHEMICAL AND PHYSICAL PROPERTIES.

CHAPTER II.

All soils cousist of mineral substances formed by the decomposition of rocks, together with humus substauces produced by decaying plants, and their value depends chiefly on the amount of decomposition they have undergone.

For a soil to be of any agricultural value, it is necessary that it should contain the various constituents of plant life, iu such condition as to be easily assimilable by the growing plant, and this condition is only to be obtained by the constant exposure to the atmosphere of different particles of the soil.

Almost all soils contain these constituents, but in greatly varying amounts and in different combinations, some of which are so insoluble that they are practically valueless until by the continued action of the weather they have become disintegrated and liberated in an available form. The rocks from which soils are formed differ greatly, some producing by their decomposition poor sandy soils, and other clays more or less pure; neither of these classes of soil are very fertile, some being almost barren; but when a soil is formed from a mixture of the two, it is usually of fine quality and its mechanical properties are improved.

The richest class of soils are generally those that have been formed by the deposition of suspended matter from running water, as this matter has been derived from the decomposition of the various rocks and soils of the different districts, through which the river has passed, and the more mixed the material from which it is formed, the more valuable is the soil agriculturally.

There are several agencies on which the conversion of rock into soil is dependent, such as changes of temperature, the mechanical action of water, ice, and air, the chemical action of saline solutions and the oxygen and carbonic acid of the air, also the action of vegetable and animal organisms, all of which act in their various ways to reduce the hard mass of any rock to particles of more or less minuteness, and gradually by their continued action to change the insoluble plant food into a readily available form.

Changes of temperature cause alternate expansion and contraction of the different materials in the rocks, which tend to disintegrate them and cause the surface, which is most exposed to these changes, to gradually crumble away ; this friable material is then washed down by the rain to the nearest river or stream, and is carried away to a distance, depending on the force of the current and the size of the particles, and is again deposited to form new soil at a lower level, where the flow of water is too slow to retain it in suspension.

The mechanical action of water is very great especially in districts where the rainfall is large and the country hilly, and its effects are visible in the turbidity of any river after a fall of rain, and also in the serious effect it has on exposed hill soils.

The chemical action of water, consists chiefly in its combining with some ingredient in the rocks, forming thereby a bulky hydrated compound, which by its expansion breaks up the surrounding particles of rock or soil, and allows them to be washed away. It also has a solvent action on certain constituents, especially when it contains oxygen, carbonic acid, or certain saline matter in solution, and by dissolving these constituents the continuity of the rock is broken and disintegration results. Lime in solution in water in the form of bi-carbonate has a greatly increased action on the alkalies locked up in the soil, dissolving and liberating them for the use of the plant.

The chemical action of the air depends chiefly on the oxygen, this being the chief agent of chemical change in rocks and soils. It combines with certain substances, as the lower oxides of iron, causing expansion by the more bulky compounds formed ; it oxidises other substances including organic matter, forming certain mineral and organic acids, which are capable of dissolving minerals insoluble in pure water.

The action of vegetable organisms or plants on the disintegration of rocks, is by their tendency to keep the soil moist, and in a favorable condition for decay. Also by the power of the roots of plants to dissolve by means of an acid secretion certain constituents otherwise insoluble, and by their growth to burst the particles of rock On the decomposition of the plants themselves, their carbon is oxidised to carbonic and other organic acids, which when in solution have a powerful solvent action. Some soils are formed almost entirely from the growth and decay of plants ; in this case the yearly growth is more rapid than the decay owing to a limited supply of oxygen, and accumulation of humus and peaty matter gradually results. Such soils are often of great depth, and are exceedingly rich as they contain all the elements of plant food stored up in an easily available form, ready for the use of any plant that may be grown on them. Their decomposition is however greatly hastened by all methods of cultivation and they are not so lasting as soils formed from the decomposition of rocks alone. By cultivation the organic matter is more completely exposed to the action of the oxygen of the air, when it is oxidised to carbonic acid or other compounds soluble in water, which are then washed away by the rain.

The action of lower animals, as worms, lies chiefly in the improvement rather than in the formation of soils ; they act by loosening the soil, making it pervious to rain and the roots of plants, and enrich it by the organic matter, leaves, &c., which they carry below the surface, there to undergo decomposition and decay. They are generally only found to a large extent in soil that is fairly rich, and their presence may be looked upon as an indication of good soil.

There are certain conditions which affect the *fertility* of a soil, these being,—

1. Latitude, longitude, and altitude, affecting the climate.
2. Slope and aspect, affecting the drainage and temperature of the soil by the heat from the sun's rays.
3. Proximity to hills or forests, affecting the rainfall and mean temperature.
4. The chemical and physical nature of the soil.

All these conditions should be taken into consideration in selecting a soil.

As regards the physical properties of a soil, its state of division has a great effect on its fertility, usually the most finely divided being the most fertile, if the division is not so fine as to form a very compact and adhesive clay, which would prevent the proper spreading of the roots of a plant. The more finely divided a soil is within this limit, the greater the amount of plant food available from a given area.

The capillarity of a soil is also very important and increases with the fineness of division, a soil having good capillary action being less liable to suffer from drought during a dry season, as moisture will be continually drawn to the surface from a greater depth. A clay soil will draw moisture by its capillarity alone from a depth of six feet, while a sandy soil would not draw half that distance.

The hygroscopic power of a soil varies, but increases with the proportion of organic matter or humus present; for this reason sandy soils, which have little hygroscopic power, are greatly improved and rendered less liable to drought, by the addition of vegetable matter in any form.

The evaporative power together with the hygroscopic power of soils are of importance as affecting the question of drainage. A sandy soil having little hygroscopic power and great evaporative power, requires some means to be adopted for retaining moisture, rather than to remove it, whereas with clay or humus soils, which have great hygroscopic and little evaporative power, drainage is necessary to remove any excess of moisture, which otherwise would be retained to the injury of any plant. The effect of prolonged drought on an *undrained* heavy clay soil, is to cause contraction by as much as 8 to 18°/o resulting in great injury to the rootlets of plants, as in drying the soil hardens round them and frequently causes rupture.

Evaporation is greatest when the soil is occupied by a crop, and will be in proportion to the activity of its growth and the extent of its root development. On uncropped soil, evaporation is greatest when the soil is consolidated, and the conditions are consequently favourable to capillary action, while it is least when the surface soil has been broken up by tillage, as the subsoil water cannot then reach the surface by capillary attraction.

The relation of soil to heat is another important physical property, as the more quickly it absorbs, and the longer it retains heat, the more favorable are the conditions for early and continuous plant growth. There is a small but almost imperceptible heat generated by the oxidation of some of the constituents of a soil, the main source of heat being the sun's rays; the actual rate of heating is however slow, especially when the soil is wet, as the constant evaporation for a long period keeps the soil cold, it can be hastened by removal of the water by drainage, as by that means the warm air can sooner penetrate to a greater depth.

The formation of soils has of course been going on for ages, and a careful examination will show that they consist of fragments of various sizes, from stones to minute microscopic particles, all of which were parts of the original parent rocks. They are continually subjected to the same forces that originally disintegrated them from the rocks, and gradually tend to be reduced to an impalpable, and finally a soluble condition, available for plant growth.

The amount of soluble matter present in an ordinary soil at a given time varies, but rarely exceeds ·3% and is generally far below this amount.

The greatest quantity is found after a long period of dry weather, when an accumulation has taken place, partly from the further decomposition of the constituents of the soil, and partly from the matter brought up in solution by capillarity from below, which had been carried down by the rain.

The proportion of plant food in soil is very small, even when the soil is extremely fertile, but the weight of soil per acre of land is so enormous, that small proportions of plant food may amount to very considerable quantities. Twelve inches depth of a dry loamy soil will weigh from 4,000,000, to 5,000,000 lbs., and every ·10% of plant food would amount to 4,000 lbs. per acre. But a large part of the elements of plant food contained in soil is present in such a condition, that plants are unable to make use of it. An acre of soil may contain many thousand pounds of the different constituents, and yet be in a poor condition, while a small dressing of readily available plant food might greatly increase its productiveness.

A sandy soil although spoken of as light, is in reality far heavier than a clay soil, the term referring to its friable qualities ; it consists chiefly of finely divided particles of quartz rock or silica, together with other minerals. Most sandy soils from any of the tea districts contain a large proportion of potash and magnesia mica in small glistening scales, which on decomposition yield a certain amount of mineral plant food. The best soils are those that contain a certain proportion of clay and humus with the sand, as their physical properties are better, and they are usually richer in available plant food.

Clay soils consist almost entirely of sand which has been ground to an impalpable powder, and contain very little pure clay, or hydrated silicate of alumina. They are more retentive than sandy soils, not only for moisture, but also for soluble plant food. They are derived from the crumbling down of felspathic rocks such as granite, the soluble alkaline portion having been partially washed away.

Pure clay is valueless as a plant food, neither the silica or alumina of which it is composed being necessary constituents of plants, but an agricultural clay is never pure, always containing an admixture of other substances. They vary in colour from blue, through yellow to red, showing the presence of different oxides of iron, iron being an important element of plant food. They are also invariably rich in potash, and generally contain all the other necessary plant constituents in fair amount, while their absorptive and retentive property for ammonia, phosphoric acid, lime, and other substances necessary for plant nutrition, makes them valuable and lasting soils.

Lime is a staple constituent of all soils either as carbonate or sulphate, and is beneficial in many ways both on account of its mechanical properties, and because it is an essential element of plant food. It has the effect of mellowing clays, and of increasing the retentive power of sandy soils, it also promotes the decomposition of organic matter, and the formation of nitrates in the soil, as it forms a base with which the newly formed nitric acid can combine, and without which this important chemical change cannot proceed. A curious circumstance, however, about most tea soils is the extremely small proportion of lime found in them ; it is never entirely absent, and is largely replaced by magnesia, which apparently forms an useful substitute in the case of the tea plant.

Vegetable matter is a constituent of all fertile soils, and usually the more they contain within certain limits the more valuable the soils. Its presence indicates fertility because a soil abounding in vegetable matter has proved itself capable of supporting a vigorous vegetation, while it causes fertility chiefly by the store of nitrogen it contains, and which on its decomposition is oxidised, and liberated in an available form. It also yields on oxidation a large amount of carbonic acid, which dissolved in water acts on the mineral matter of the soil, and is itself taken up through the roots, and elaborated in the tissue of the plants to form matter for new growth.

Vegetable matter also contains a certain proportion of mineral plant food, which has been accumulated during its growth from the soil below, and which on its decomposition is once more liberated in an available form. Organic matter has a great influence on the physical and mechanical properties of soils, and it is chiefly on these qualities that its value depends.

Soils of China, &c.—The number and description of soils on which tea will grow and flourish is very great, and there is no doubt that the quality and flavour of the tea varies with the soil on which it is produced.

The best black tea district of China is the Woo-e Hills, and it is thought, that the success which attended the cultivation of tea in that part of China was due to the peculiar formation and properties of the rocks composing these hills. They consist of clay slate, containing great masses of quartz rock, and granite of a deep black colour due to the mica, this granite forming the summit of most of the principal mountains in this part of the country. Resting on the clay slate are sandstone conglomerates formed principally of angular masses of quartz, held together by a calcareous basis, and alternating with these conglomerates there is a fine calcareous granular sandstone, in which beds of dolomite limestone occur.

The soils vary considerably, the most common being a brownish yellow adhesive clay, containing a considerable portion of organic matter, mixed with particles of the above rocks. At the foot of the hills the tea soils are darker, containing a greater portion of organic matter, but still either brownish or reddish yellow.

The Chinese, as a general rule, always prefer land which is moderately rich, provided other circumstances are favorable ; a very poor soil producing tea of inferior quality.

The finest tea of the district is produced on hill sides, the soil of which is moderately rich and contains a considerable portion of organic matter. It is kept moist by the peculiar formation of the rocks, and the water which is constantly oozing from their sides, and is well drained owing to the natural declivities of the hills, or if on the plains, by being a considerable height above the water courses. These are said to be the essential requisites, as regards soil, situation, and moisture.

In the green tea district of Hwuy-Chow, tea cultivation is carried out on the low lands, the soil of which is rich and fertile and produces a high quality tea. In the districts of Fokien and Chekiang the soil is a rich sandy loam.

One of the most accredited accounts of China gives the following analysis of the soil, probably from the black tea districts near Canton, but which cannot apply to the rich soil of the great tea districts,—84% of sand, a quantity of carbonate of iron and alumina, and only 1°/o of vegetable matter.

Mr. Ball in his work on the cultivation and manufacture of tea states—" that a tea soil should be of a texture to receive and part with its water freely; it is on the just balance between these extremes that its suitableness depends, and this again must be regulated by its locality."

Mr. Gordon, who was one of the introducers of China tea into India, states that the tea plant requires absolutely a free soil, not wet and not dry, but of a texture to retain moisture, also that it is no use to attempt cultivation of the plant in an easterly exposure, though it is sufficiently hardy to bear any degree of dry cold.

The proportion of sand in Chinese tea soils varies considerably, as may be seen in the following table :—

	Lapa.	N. E. Fokien.		Pot.	Bohea.		
Sand ...	46·1	17·70	10·	51·54	33·08	44·61	36·15
Clay (Ferruginous.) ...	53·9	56·53	90·	48·46	66·92	55·39	63·85
Fragments ...	...	25·77	...	...	...	...	...
	100·	100·	100·	100·	100·	100·	100·

These earths were all of similar ferruginous tints, *i. e.*, of light yellow or reddish brown except No. 2, which was of a grey or brownish grey tint. They were all of a clayey adhesive character, but easily crumbling and falling down in water. Only one gave evidence of the presence of carbonate of lime, and in that a single piece of the carbonate was observed, which was probably accidental. These analyses were made and reported on by Professor Faraday, Royal Institution, 1827.

The most favorable situation for tea is on the terraces of rocky hills or mountains, where the plantation receives a fair amount of sun and wind; too much of the former causing the tea to lose its delicacy of flavour.

There is a great difference of opinion as to the most suitable soil for tea, some stating that a rich compact soil is the most favorable, which appears at variance with the currently received opinions, in which it has generally been believed that tea succeeds best in a stony, gravelly sandy or poor soil, where there is little accumulation of vegetable mould.

In Nippon, Part VI.—Dr. Von Siebold states that, " the soil most congenial to the tea plant in Japan, consists of a clayey heavy soil, rich in iron, containing fragments of wacké, basalt, basaltic hornblende, and fossils peculiar to the trap formation. It is somewhat sandy and chalky, and on being washed exhibits very little vegetable mould.

An analysis of soil brought home by Von Siebold was made by Dr. Von Essenbech and L. C. Marquart. They describe it as a strong ferruginous clay, in which no mixture of sand was perceptible to the naked eye. After analysis they classed it as an intimate mixture of siliceous earth and clay, with oxide of iron and manganese. It was very deficient in carbonic acid, humus, lime, and magnesia, and in their opinion required a strong manure and an addition of alkaline matter. Its water retaining property was considerable on account of its great portion of clay, but the soil was deficient in lightness from the absence of coarse sand.

That tea would grow well on soils rich in organic matter was shown by Dr. Guillemin prior to 1840. This botanist visited the plantations of Major da Luz at Nossa Senhora da Penha, which were exceedingly well kept, and states that the ground which was almost level had formerly been under water, and had been drained at the expense of much labour by Major da Luz. The soil here he adds : " is less argillaceous than in other places, and the vast quantity of vegetable detritus, which remains in the uncultivated parts, gives it the appearance of a soil richly manured. Besides which, the plants here have a vigour of growth I have not observed elsewhere, almost all have attained the height of two or three metres, the general height of plants in the settlement not exceeding half that size. These plants therefore, mark a great luxuriance of growth, ascribable no doubt to the richness of the soil, and the quantity of decomposed vegetable matter which it contains."

Thus a considerable discrepancy of opinion seems to prevail regarding the soil, the most favorable for the cultivation of the tea plant ; but as it has been shown that the shrub possesses great powers of adaptation to climate, so also as observed by Dr. Wallich, "it may be easily satisfied with respect to soil."

Mr. M'Clelland, also, seeing the various conditions under which the tea plant grows in Assam, concludes that "there is a disposition in the plant to accommodate itself to any soil, as far at least as its vegetative powers are concerned." He found that the tea plant in Assam grew on a loose, dry and dusty soil, which sinks under the feet with a certain degree of elasticity, derived from dense meshes of succulent fibres, prolonged in every direction from various roots. The soil and sub-soil were highly porous, and different in this respect from the structure of the surrounding surface of the country. He also found that the peculiar character of the soil in regard to colour, consistency, and inequality of surface disappeared with the plant itself, beyond the extent of a circular space of about 300 yards in diameter.

Subjoined are two analyses of soils, No. 1 being a specimen of the soil in which the tea plants were most abundant. No. 2 that of the common soil of the district taken about 500 yards beyond the boundary of the colony.

No. 1.—Constituent parts, per cent.

Water	18·50 %	Colour, light grey, fine dusty sand without consistency, rough between the fingers, without smell.
Fresh fibres	·50 ,,	
Vegetable matter	2·62 ,,	
Silex	67·50 ,,	
Alumina	5·50 ,,	
Oxide of Iron	2·37 ,,	
	96·99	

No. 2.—Constituent parts, per cent.

Water	26·00 %	Colour, greyish black moist, uniform, firm and solid. When rubbed between the fingers this soil possesses considerable coherency and softness.
Extractive matter	2·50 ,,	
Vegetable matter	4·25 ,,	
Silex	57·00 ,,	
Alumina	4·75 ,,	
Oxide of Iron	2·00 ,,	
	96·50	

Another soil on which the tea plants were so numerous as to form one-third of the entire vegetation of the spot was light, red, dry and dusty, raised about five feet above the surrounding ground which was covered with reeds.

The colour of the surface was a dark yellowish brown, but on being opened it appeared much brighter, and on sinking to the depth of three feet, changed progressively to a deep, pure orange coloured sand, quite distinct from any of the other soils or sub-soils in that part of the district.

The red soil disappeared gradually within the limits occupied by the tea plants. The level of the waters in the wells in this neighbourhood, were about ten feet below the surface of the ground. Mr. M'Clelland observes finally with respect to the soils and situations, that the tea plant is found in Assam, first on the level plain, and second on mounds somewhat raised above the plain. The first situations are distinguished from the rest of the plain by a porous structure, and the peculiar character of maintaining a dry surface under exposure to excessive moisture; the second by a structure less porous than the first. In both, the plants are situated above the range of inundations, which prevail during the greater portion of the year on the adjoining lands, and which are evidently prejudicial to the growth of tea, although they act beneficially to the adjoining lands.

Although the tea plant was commonly found growing on the banks of rivers, jheels, &c., where there was plenty of moisture, all the older authors are agreed that it will not grow in soil in which the water is stagnant, and on the necessity of the soil being open and porous.

As regards the question of whether the soil affects the quality of tea, a Spanish Missionary who gave a valuable account of the tea plant, observes: "In the province of Fokien, there are many plantations, where the care and the method of preparing tea are nearly the same, whilst the tea is very different, whether we consider the leaves, the flavour, or the effects which it produces; consequently the nature of the soil cannot be the same." The Chinese themselves sufficiently prove this by their frequent declaration that the soil occasions the principal difference in the quality of tea.

The conclusion arrived at by Mr. Ball from answers to questions on the subject of soil and situation of tea are "that the tea shrub delights in very high situations, a compact and rich soil, a temperature cold and humid, and an eastern aspect.

The Chinese also say of the soil of Fokien that :—

" There are some plantations on plains rather low, the soil of which "is very compact, a little muddy, black, neither very cold nor very hot, "and rather damp. The tea from this soil is worth two thirds more "than that of other parts of the same district (Fokien), but the "best of all. is procured from plants, which are upon high mountains, "in steep places something like precipices, where iron chains are "used to ascend them to gather the leaves. As all the tea, which is "found upon the neighbouring mountains is of quite a different kind, "although the temperature is the same, it necessarily follows that the soil, "must be different."

When tea was first introduced into India, soils at considerable elevations in the Himalayas, were selected, some of which have been described by Mr. Fortune :—

The soil of one plantation consisted of clay, sand and vegetable matter, rather stiff and apt to get baked in dry weather, but free enough when moist. It rests upon a gravelly sub-soil, consisting of limestone, sandstone, clay, slate and quartz rock ; the surface is comparatively flat although it falls towards the ravines and rivers.

Another, the soil consists of a mixture of loam, sand and vegetable matter, is of a yellow colour and most suitable to the cultivation of the tea plant ; it resembles greatly the best tea districts of China. A considerable quantity of stones are mixed with it, chiefly small pieces of clay slate of which the mountains are composed.

Another, the soil is a sandy loam, moderately rich and well mixed with vegetable matter, being well suited for tea cultivation. Other soils of similar description are also mentioned, and Mr. Fortune sums up by stating that " Tea, in order to be profitable, requires a good sound soil,—a light loam well mixed with sand and vegetable matter, moderately moist, and yet not stagnant or sour." The correctness of Mr. Fortune's opinion has been well proved in later years. Every planter knows now the necessity of having a sound rich soil, with perfect drainage, in order that a large outturn of good quality tea may be obtained.

The opinion that soil affects the quality and flavour of tea is no doubt correct, especially as regards "strength of liquor," but temperature and climate generally have an equally important influence on the formation of the constituents to which the flavour of tea is due.

Flat but elevated lands appear to have been planted with tea from its first introduction into India ; Mr. Fortune in his report on his inspection of the Himalayan plantations remarks, "that he dees not approve of them, the bushes being generally not so vigorous as those on hilly land, apparently owing to the want of drainage."

The sites and soils first selected in Cachar were the small teelas, which are prevalent throughout most of the district. The soil of these teelas varies considerably, but most of them are sandy and easily friable, while in certain districts hard pieces of volcanic rock called "laterite" project through the surface. Most of these soils have little adhesive power, and cultivation together with the heavy rainfall of the district, soon caused the finer portions of the soil to be carried away and deposited in the bheels and valleys between them. With this wearing away of the soil, the plants also deteriorated, and it became necessary for planters to adopt some means of renovation. This has largely been done by the carrying up, and replacing of the soil from the bheels beneath.

About 1870, it was found that tea would grow well on the bheels themselves, after they had been opened up and well drained, and since that period immense areas of this kind of land have been cleared and planted.

The first tea was imported into Java in 1827 from Japan, and in 1829 tea was also imported from China, the Chinese tea being better than that from Japan. Mr. Jacobson gives the following description of Java tea soil :—

A good tea soil of a mild nature, consists of half to three-quarters of a foot of marsh land, under which it is brown, stiff and clayey. It should not be rich, somewhat sandy, sufficient to make it light and loose when broken up.

High flavoured but gross tea is produced on some rich, marsh land met with in the high hill country of Java 3—4000 feet. It is finely ground, soft, black, and light as garden mould to a depth of 9 inches, deeper it is a dark coffee brown, and below 2 feet the clear brown and yellowish hill soil appears in the vicinity of such soils ; good tea soils are found where the upper surface has been already cultivated or washed away, the resulting soil being rich but tempered and profitable for tea cultivation.

Old lava lands are to be recommended. The finest tea is produced on stony, clayey and such lands as have sand mixed with them. Fairly stony lands are favorable as they always contain moisture. On hills where the masses of stone are large and the fissures filled with good soil, plants flourish well, provided they can send their roots to a depth of at least two-and-a-half feet.

The following is the description of a soil of a Japanese tea plantation :—

"Very uniform, fine grained mixture of a yellowish grey colour having altogether the appearance of a strong ferruginous clay, in which no mixture of sand was perceptible to the naked eye."

"It contained ·062 % of matter soluble in cold water consisting of humus and lime, with traces of muriatic and sulphuric acids clay and iron."

The percentage composition was—

Siliceous earth	53 %
Oxide of Iron	9 ,,
Clay	22 ,,
Oxide of Manganese and Magnesia ...	·5 ,,
Gypsum	·5 ,,
Humus	1·0 ,,
Phosphoric Acid (Traces of)	
Hygrometric Water	14·0 ,,
	100·

Traces of potash were also detected, which was not present in the soil as a soluble salt, but combined with clay and silica.

This soil from its deficiency in carbonic acid, humus, lime, and magnesia is far from being a productive soil, and requires a strong manure and addition of alkaline matter.

Tea soils of Assam, &c.—The soils on which tea is grown in India and Assam vary considerably both in physical properties and chemical constitution. Most of them are of the class known as "transported soils" that is, brought down and deposited from running water ; a few perhaps are formed from the decomposition of the rock beneath, and are known as "sedimentary soils," and the remainder are the peat or bheel soils formed as described above.

From the accounts given by the different authors who have written on the subject, it is very evident that tea will grow on almost any kind of soil irrespective of mechanical composition, but its growth and leaf-bearing qualities depend chiefly on the physical and chemical properties of the soil.

Soils which yield the best return as regards quantity and quality are the pale, reddish coloured rather sandy loams, containing a good proportion of organic matter, and with an open and free sub-soil allowing easy penetration of water and the roots of the plant. They also contain a good amount of readily available plant food, although the percentage of mineral matter soluble in cold water is never at any period very large.

But with the richest of soils the outturn of tea would not be very great unless the climatic conditions were also very suitable, these being an abundant and well distributed rainfall, and a warm temperature, which varies little throughout the growing season.

The best soils are usually those which have grown forest for an unknown period of years, and which have been annually enriched by the fall and decay of the leaves of the trees. They contain near the surface an abundance of organic matter and nitrogen together with the mineral matter, which has been taken from the soil and sub-soil by the roots of the trees, and stored up in the leaves.

On the gradual decay of the leaves, which is hastened by clearing and cultivation, these mineral and organic constituents are liberated in the soil, in a form which is easily dissolved by rain water, and which would to a large extent be removed and lost by drainage, if no plants were put into the soil to utilise it.

These forest soils are usually porous and open, owing partly to their mechanical composition, also to the presence of innumerable roots and rootlets, which on their decay leave open channels for the free passage of air and water.

The difference between soils obtained from forests and grass lands, lies more in their chemical composition than in their mechanical and physical properties, as analysis often shows them to contain about the same relative proportions of sand and clay. The latter are usually poorer in organic matter and nitrogen, and richer in mineral constituents than forest lands, which is easily explained. Most grass lands are burned annually during the cold weather either intentionally or otherwise ; this burning causes the dissipation in the air as gases of almost all the organic matter, that has been accumulated from the soil and atmosphere during the preceding year ; consequently a loss to the soil of both carbon and nitrogen annually takes place. At the same time all the mineral constituents that have been taken up by the plants, are returned to the surface soil as ash, which are again utilised by the succeeding crop.

They are often more compact in character than forest soils, owing probably to the treading of cattle, to being exposed directly to heavy falls of rain, and to the absence of deep roots, which tend to open the soil.

Bamboo forest soil has been found very suitable for tea, being light and friable in character and easily drained.

Peaty soils such as are found in Cachar and Sylhet, but more rarely in Assam, have a marvellous power of causing tea to yield rapid and heavy flushes, but such tea is not of very good quality and has little or no flavour. But after they have been opened out, drained and cultivated for two or three years, the quality of the tea gradually improves without the quantity decreasing to any extent. When first opened out, these soils are very rank and sour in character, due to the want of proper oxidation by the air, which has been prevented by the dense under growth of the jungle excluding the air, and to the presence of an excess of stagnant water in the soil itself.

By the burning of the jungle, when cut, a large quantity of mineral matter is given to the soil in the form of carbonates, which assist in neutralising the acid humic matters contained therein, and rendering the soil fit for the growth of cultivated plants. This change is also assisted by the cutting of deep drains to remove all stagnant water containing effete and poisonous matters in solution.

The depth of bheel soils varies from 2′ to 10′ or more, and usually below them there is a dense sub-soil of blue clay, the colour being due partly to certain organic substances, and partly to the presence of the lower oxides of iron, which are distinctly poisonous to plants.

When the soil is not very deep and the roots of the tea are likely to penetrate to a sub-soil of the above description, it would be necessary first to dig drains of some depth into the sub-soil, and so cause aeration and oxidation of the iron compounds, otherwise when the roots of the plants descended, they would absorb these poisonous constituents, which would either check their growth or kill the plants entirely.

Peaty bheel soils undergo a great change and loss when under cultivation, due to the combined action of the air and rain on the organic matter, which is rapidly oxidised to carbonic acid, and either washed away or given into the atmosphere as gas. Owing to this rapid and serious loss of organic matter and nitrogen, it is necessary to adopt some means of lessening it as much as possible, and this would be best done by limiting the amount of cultivation or hoeing given throughout the year. It must be remembered that these soils are already very light and porous, and when well drained admit air freely into their interior, so that cultivation is not so necessary as when the soil is more compact, and need only be done to bury the jungle when it attains a size, that would interfere with the growth of the bushes. By adopting such a system, the amount of organic matter decomposed would be almost, if not quite, replaced by that obtained from the atmosphere by the buried jungle, and deterioration of the soil would be largely prevented. The well known luxuriant growth of tea or other plants on such soils is due in a great extent to the rapid decomposition of the organic matter, which affords an abundant supply of carbonic acid for the use of the growing plant.

Another class of soils on which tea is largely grown are the light teela soils on which tea was first planted when introduced into Cachar.

Some of these soils when first cleared must have been fairly rich and strong, from the appearance of the jungle and forest growing on uncleared teelas at the present time, but they have in almost every case rapidly deteriorated, more from the amount removed by wash and heavy rainfall than from what has been removed by the tea itself.

When protected from direct rainfall by the jungle growth they gradually increased in richness and value in the same way as other forest soils, but after the jungle was cleared away and the surface soil loosened by cultivation, they were washed down from the summit and slopes of the teelas, and helped to form and enrich the bheel soils beneath.

Attempts have been made with a certain amount of success to prevent this wash by terracing the slopes of the hills, but in many cases this was only done, when the best of the soil had been washed away, and the effects were not so beneficial as they would have been, had the terraces been made when the teelas were first cleared.

The character of these teela soils does not vary much, being generally a light sandy loam, formed from the decomposition of the laterite rock beneath, but occasionally the soil rests upon a pebbly sub-soil, which fact together with the sharp slopes makes drainage too excessive, so that the bushes are very liable to suffer from drought, in any but a very wet season.

In a few instances the base of the teelas is formed of a dense whitish clay, which yields a soil very unsuitable for the successful growth of tea, but the outcrop of such a soil is usually very small in extent, and beyond its effect on the drainage of the teelas in which it occurs, its presence is of little importance.

Some bheel soils which have been opened out and planted with tea are very heavy in character, being composed almost entirely of a stiff blue clay, which at first has a most unpromising appearance; however when deeply drained at close intervals and thoroughly cultivated for a year, the character of the surface soil undergoes a change in appearance and becomes more gritty and sandy, from the removal of a part of the almost impalpable matter in the soil. This alteration in character proceeds gradually deeper into the sub-soil as the drains become more active, until at last the blue colour almost entirely disappears, having changed to a pale and gradually deepening yellow.

When this change has taken place, the soil appears to grow tea luxuriantly, and such a soil will probably prove far more lasting than the peaty bheel soils mentioned above, owing to its retentive character for the bases liberated by cultivation and exposure of the soil to the atmosphere.

The drainage water from most newly opened bheels contains much oxide of iron, which is present in the soil in the form of the lower oxide, and which is gradually deposited after exposure to the atmosphere as the higher or red oxide. It is also invariably very acid, owing to the presence of several organic acids in solution, which are very detrimental to the healthy growth of tea, and should be removed by drainage, or neutralised by lime, prior to any bushes being planted out.

If this precaution is not taken, it frequently happens that although the plants live, their growth is checked for some months until the necessary changes have taken place, and it will be found that such plants will never flush or grow as luxuriantly as those which are planted after the soil has been sweetened by drainage and cultivation. I will now give the mechanical and chemical composition of several typical tea soils, obtained from various parts of the tea districts.

No 1.—A soil, taken from the Dam-Dim District in the Dooars, which was planted with tea in 1890. It was a reddish sandy loam, in a fine state of division, containing much potash mica, and occasional fragments of granitic and slatey rocks. The land was naturally well drained and the young plants were healthy and strong. The soil before being opened carried good timber forest.

Chemical Composition.

	Soil 18″ deep.	Subsoil to 3′ deep.
*Organic matter aud combined water ...	5·95 %	4·44 %
Sand and Silicates	78·35 ,,	80·73 ,,
Soluble Silica	1·04 ,,	·60 ,,
Lime (CaO)	·07 ,,	·16 ,,
Potash (K_2O)	1·02 ,,	·30 ,,
Manganese (Mn_3O_4)	...	·40 ,,
Alumina (Al_2O_3)	7·27 ,,	9·04 ,,
Oxide of iron (Fe_2O_3)	6·52 ,,	4·26 ,,
Phosphoric acid (P_2O_5)	·09 ,,	·07 ,,
	100·	100·

* Containing Nitrogen equal to Ammonia	·344 %	·19 %
Ditto ditto Nitric Acid	·004 ,,	·0003 ,,
Chlorine equal to salt (NaCl) ...	·0049 ,,	trace.
Soluble salts and humus substances ...	·124 ,,	...

No. 2.—A soil from the same district, but had been under tea for some years, greyish colour, very finely divided and full of mica. The bushes were fairly healthy, but had fallen off in yield, partly owing to age, and partly to the readily available plant food having been largely used up. The composition does not differ materially from the above, but the constituents were in a more insoluble condition, the soil containing only slight traces of plant food soluble either in pure cold water, or in water saturated with carbonic acid.

No. 2—*Chemical Composition.*

* Organic matter and combined water ...	7·27 %	5·39 %
Sand and Silicates	77·55 „	79·64 „
Lime (CaO)	·17 „	·15 „
Potash (K_2O)	1·91 „	·71 „
Manganese (Mn_3O_4)	1·26 „	2·17 „
Alumina (Al_2O_3) / Oxide of Iron (Fe_2O_3) ...	12·16 „	11·81 „
Phosphoric Acid (P_2O_5) ...	·09 „	·05 „
	100·41	99·92

* Containing Nitrogen equal to Ammonia	·365%	·134%
Ditto. equal to Nitric Acid ...	trace	trace
Soluble salts and humus substances ...	·026%	...

No. 3.—A soil from another district in the Dooars.

This was very light and friable, consisting chiefly of quartz and micaceous sand, and had little retentive power for moisture. The sub-soil was similar in character to the soil, but rather more stony and open. It was found that tea plants in this soil died out in the dry season, and even when planted in the rains only produced a small sickly growth. This was due partly to the poor nature of the soil, but more especially to its over drained condition from its porous sub-soil and sloping aspect, which prevented the young plants from reaching moisture during the dry season.

Mechanical Analysis.

	Soil.	*Sub-soil.*
Fine earth	24·7 %	18·7 %
Sand	49·6 „	46·1 „
Coarse sand	22·5 „	18·6 „
Stones $\frac{1}{4}''-\frac{1}{2}''$	3·2 „	16·6 „
	100·	100·

Chemical Composition.

	Soil.	*Sub-soil.*
* Organic matter and combined water ...	8·19 %	6·17 %
Sand and Silicates	80·19 „	83·27 „
Lime (CaO)...	·06 „	·06 „
Potash (K_2O)	·54 „	·41 „
Magnesia (MgO)	trace.	trace.

	Soil.	Sub-soil.
Manganese (Mn_3O_4)	trace.	trace.
Alumina (Al_2O_3) / Oxide of Iron (Fe_2O_3)	10·92%	10·04%
Phosphoric Acid (P_2O_5)... ...	·10 „	·05 „
	100·	100·

* Containing Nitrogen equal to Ammonia ·13% ·10%

Both soil and sub-soil are poor in the most important constituents, and would require the *constant* application of manure to obtain a fair outturn, as they have little retentive power either for moisture or manurial matter. The bushes also on such a soil, even if deeply rooted, would be liable to suffer from drought during a prolonged dry season, as the subsoil is very open to a great depth.

No. 4.—Another soil from the Dooars on which tea would not grow during the wet season.

It was of a light grey colour, in a very fine state of division, had a soapy touch, and when moistened with water, set almost like a cement

Mechanical Composition.

	Soil.	Sub-soil.
Moisture	8·6 %	15·8 %
Fine earth	42·0 „	14·0 „
Fine sand	16·8 „	17·0 „
Sand	6·0 „	14·0 „
Coarse sand	26·6 „	39·2 „
	100·	100·

Chemical Composition

Moisture	5·000 %
Organic matter, and combined water ...	2·735 „
Sand and Silicates	79·616 „
Lime ($CaCO_3$)= 1·5 % (CaO)	2·683 „
Potash (K_2O)	1·330 „
Magnesia (MgO)	1·800 „
Alumina (Al_2O_3) / Oxide of Iron (Fe_2O_3)	6·043 „
Phosphoric Acid (P_2O_5)	·170 „
Soda, &c., undetermined (Na_2O)	·623 „
	100·

The iron was present almost entirely as the lower poisonous oxide, and this together with the large amount of impalpable matter and silicate of magnesia, which when wet, would choke the rootlets and prevent the absorption of plant food, and was the probable cause of the tea bushes dying out as soon as the rainy season commenced.

No. 5.—A rich bheel soil from Assam (Nowgong District) which was very favorable for the growth of tea. It had highly retentive properties, both for moisture and manurial matter, owing to the large amount of organic humus substances and alumina contained in it. It contained only a trace of lime however, and apparently would be benefitted by an application of that constituent, as a certain quantity is removed annually by the leaf. To prevent hastening the destruction of the organic matter, the lime in this case would be best applied as carbonate, as the soil had only a very slight acid reaction when moistened, from the organic acids present.

Chemical Composition.

Moisture (in air dried soil)	17·18 %	...
* Organic matter and combined water ...		14·74 %
Sand and Silicates		70·10 „
Soluble silica (SiO_2)		·94 „
Lime (CaO)	trace	...
Potash (K_2O)		·81 „
Magnesia (MgO)		·24 „
Manganese (Mn_2O_3)		1·82 „
Alumina (Al_2O_3)		9·28 „
Oxide of iron (Fe_2O_3)		2·00 „
		100·

* Containing Nitrogen equal to Ammonia ... ·694 %
Ditto ditto Nitric Acid (N_2O_5) ... ·001 „

The luxuriance of growth was probably chiefly due to the large amount of nitrogen present in the soil, and conditions being favorable for nitrification, the magnesia taking the place of lime, as a base with which the newly formed nitric acid could combine.

No. 6.—A soil from the same district as the above, which had grown tea for years and was still yielding well. A peculiar feature of this soil and of three others obtained from the same district, was the large amount of phosphoric acid contained in them, amounting in each case to about ·5%. The application of phosphates such as bones, &c., to such a soil would probably have little beneficial effect, notwithstanding that most of the phosphoric acid was combined with iron or alumina, forming an insoluble phosphate.

Chemical Composition.

Moisture	...	8·49 %	...
*Organic matter and combined water	...		4·30 %
Sand and Silicates	...		85·47 ,,
Lime (CaO)	...	trace	...
Potash (K_2O)	...		·41 ,,
Magnesia (MgO)	...		·50 ,,
Manganese (Mn_3O_4)	...		·58 ,,
Alumina (Al_2O_3)	...		5·12 ,,
Oxide of Iron (Fe_2O_3)	...		3·06 ,,
Phosphoric Acid (P_2O_5)	...		·56 ,,
			100·00

*Containing Nitrogen equal to Ammonia... ·253 %
Ditto ditto Nitric Acid... trace.

No. 7.—Another soil from the same district, under young tea yielding a large outturn.

Chemical Composition.

Moisture	...	3·25 %	...
*Organic matter and combined water	...		4·70 %
Sand and Silicates	...		86·49 ,,
Lime	...	trace	·30 ,,
Potash			
Magnesia	...		·50 ,,
Manganese	...		·75 ,,
Alumina	...		1·03 ,,
Oxide of Iron	...		5·71 ,,
Phosphoric Acid	...		·52 ,,
			100·

*Containing Nitrogen equal to Ammonia ·257 %
Do. equal to Nitric Acid ... ·0003 ,,

No. 8.—A soil from the Jorehat District in Assam, which had been under grass, and grazed or burned annually. In appearance it looked favourable for the growth of tea, but the jungle on it was not very luxuriant and did not indicate much richness, a fact which was borne out by the chemical composition.

Moisture	...	2·40 %
*Organic matter and combined water	...	3·13 ,,
Oxide of Iron and Alumina	...	5·77 ,,
Lime	...	·01 ,,
Magnesia	...	·16 ,,
Potash	...	·28 ,,
Phosphoric Acid	...	·02 ,,
Sand and Silicates	...	88·23 ,,
		100·

*Containing Nitrogen equal to Ammonia ... ·40 %

The surface of this soil was very poor in Nitrogen, but the quantity increased a foot below the surface, owing to nitrates having been washed downwards by the rain. Such a soil it would be hardly profitable to plant out with tea, especially if good forest land was available, as under present conditions of the Tea Industry, it is only the best kinds of soil, that will pay to open out, and the higher expenditure necessary for clearing forest in the first instance, is likely to prove the more remunerative in the end.

No. 9.—A soil from the same district only under forest instead of grass, on which tea grew fairly, but not very luxuriantly. It was a yellowish, rather heavy loam and required drainage to admit air to a greater depth and to remove any stagnant water. Its composition does not point to its being very rich.

Chemical Composition.

Moisture	...	1·85 %
*Organic matter and combined water	...	4·24 ,,
Oxide of Iron (Fe_2O_3) } Alumina (Al_2O_3) }	...	4·87 ,,
Lime (CaO)	...	·01 ,,
Magnesia (MgO)	...	·16 ,,
Potash (K_2O)	...	·22 ,,
Phosphoric Acid (P_2O_5)	...	·01 ,,
Sand and Silicates	...	88·64 ,,
		100·

*Containing Nitrogen equal to Ammonia ·43 %

No. 10.—A soil from the same district. The site had been used as a nursery, the plants having been removed in the usual manner, by which most of the surface soil was taken away. It was planted with tea, and as the plants did not do well, was manured with a mixture of superphosphate and saltpetre. The analysis was made some time after the manure was applied, and shows the soil to have contained an excess of nitrogen, a condition I have also found in other soils that would not grow tea, especially such as were the sites of old villages. This excess of nitrogen, is not all in the form of nitric acid (saltpetre) as might have been expected, but is in some state, insoluble in pure water, but from which it probably can be easily liberated and oxidised when the soil is subjected to cultivation. It may be in a condition or form, which can be acted upon by, and which is poisonous to plants, as the quantity of nitrogen found does not always prevent the growth of tea, for in a rich peaty bheel soil, which grew tea luxuriantly, I also found a similar amount. The soil was a heavy loam, with a sub-soil approaching to clay, and would be much benefitted by deep drainage. It is always unadvisable to plant out land, that has been the site of old villages, until they have been thoroughly drained, cultivated, and if possible limed, to sweeten and remove any sourness. I have seen several sites planted out before such operations were performed, with the result, that the plants remained stunted for some years, and even when drainage, &c., had been done later, such plants never recovered the early check in their growth, owing to the unhealthy formation of their roots. The soil contained an unusual amount of matter soluble in water, but this was partly due to the application of manure, and as it only contained a very small quantity of chlorides, the amount present was not injurious.

Chemical Composition.

Moisture	·90	%
*Organic matter and combined water ...	2·57	,,
Oxide of Iron and Alumina... ...	4·07	,,
Lime	·45	,,
Magnesia	·08	,,
Potash	·13	,,
Phosphoric Acid	·11	,,
Sand and Silica...	91·69	,,
	100·	
*Containing Nitrogen equal to Ammonia	1·19	%
Soluble Salts	·41	,,

No. 11.—A soil from the Hailakandy District of Cachar. This was a heavy clay loam of average fertility that had been under tea for several years. It was exceedingly poor in organic matter and nitrogen, and required drainage and the application of a good general manure, or the hoeing in of large quantities of green jungle to lighten the soil, and increase the amount of humus matter. It was excessively retentive of moisture.

Chemical Composition.

	Soil.	Sub-soil.
Moisture ... ... 18·21% ...		10·06 % ...
*Organic matter and combined water	2·13 %	·55 %
Sand and Silicates	78·37 „	72·77 „
Lime (CaO)	·14 „	·15 „
Magnesia (MgO)	90 „	·78 „
Potash (K_2O)	1·85 „	·71 „
Manganese (Mn_3O_4)	·21 „	·11 „
Oxide of Iron (Fe_2O_3)	7·00 „	7·20 „
Alumina (Al_2O)	9·16 „	17·65 „
Phosphoric Acid (P_2O_5) ...	·24 „	·08 „
	100·00	100·

	Soil.	Sub-soil.
* Containing Nitrogen equal to Ammonia	·22 %	·144 %
Soluble Salt and humus subtances ...	·05 „	·043 „

The high retentive quality was due to the large amount of Alumina (clay) present, especially in the sub-soil, and this could only be altered and remedied by deep and close drainage, which would soon tend to reduce the adhesive character of the soil, and allow the roots of the tea bushes, with their innumerable small fibres and fleshy spongioles to extend their growth with greater facility.

No. 12.—A soil from North Cachar. This is a very sandy ferruginous soil, from a teela that had been under tea for several years, and from which the original surface soil had been largely removed by drainage. It is exceedingly poor in almost every plant constituent, and would require the frequent application of large quantities of general manures to increase the outturn of leaf. Similar soils are sometimes much improved by a heavy top-dressing with bheel soil, rich in organic matter and nitrogen, but owing to the excessive drainage from the sharp slopes, and the small retentive power of the sandy soil for any manurial matter, most of it would be washed away from the plants before they could utilise it, and the benefit derived would be only temporary. Terracing, followed by bheel-soiling, would prevent the washing away of the manure to some extent, but the expense and labour required unless the plants were in a fairly good condition, would make the operation prohibitive.

Chemical Composition.

Moisture	3·62 %	...
*Organic matter and combined water	...	2·66 %
Sand and Silicates	...	92·17 ,,
Soluble Silica	...	·01 ,,
Lime	trace	...
Magnesia	...	·04 ,,
Potash	...	·20 ,,
Manganese	...	·06 ,,
Oxide of Iron	...	2·09 ,,
Alumina	...	2·73 ,,
Phosphoric Acid	...	·04 ,,
Sulphuric Acid	trace	...
		100·00

* Containing Nitrogen equal to Ammonia ... ·062 %

Extract soluble in water, salts and humus substances ·012 ,,

No. 13.—A soil from the same garden taken from low flat bheel land between the teelas. It was a compact stiff blue clay, coloured partly with organic matter and partly with the lower oxides of iron, which required oxidation to remove their poisonous properties. Where it had been opened out and thoroughly drained, the character of the soil became changed, and tea grew on it luxuriantly; but from the poorness of the soil in nitrogen, it would probably soon require a dressing of some manure containing that constituent, such as the various oil cakes, in order to keep up the outturn. Lime, as carbonate or sulphate (Gypsum) would also be beneficial, but in the case of tea, magnesia appears to be capable of replacing lime to a certain extent, and the soil is fairly well supplied with that constituent.

Chemical Composition.

Moisture	7·24 °/o	...
*Organic matter and combined water ...		3·90 °/o
Sand and Silicates		84·75 „
Soluble Silica		·17 „
Lime (CaO)	trace.	...
Magnesia (MgO)		1·08 „
Oxide of Iron (Fe_2O_3)		6·07 „
Alumina (Al_2O_3)		3·56 „
Potash (K_2O)		·31 „
Phosphoric Acid (P_2O_5)		·16 „
Sulphuric Acid (So_3) ...	trace.	...
		100·

*Containing Nitrogen equal to Ammonia ... ·13 °/o
Do. equal to Nitric Acid ... ... ·001 „
Extract soluble in water, salt and humus substances ·023 „

No. 14.—A soil from Central Cachar, very finely divided ferruginous sandy soil from an old teela, which had been under tea for several years, and was similar in character to *No. 12.*

Mechanical Composition.

Moisture	8·13 °/o
Fine sand and clay	69·15 „
Sand	4·29 „
Gravelly sand	4·86 „
Stones	13·57 „
	100·

Chemical Composition.

Moisture	7·06 °/o	...
* Organic matter and combined water ...		3·78 °/o
Sand and Silicates		89·63 „
Soluble Silica (SiO_2)		·12 „
Lime (CaO)		·06 „
Magnesia (MgO)		·23 „
Oxide of Iron (Fe_2O_3)		3·26 „
Alumina (Al_2O_2)		2·37 „

Potash (K_2O)	...	...	...	·21 °/ₒ
Phosphoric Acid (P_2O_5)		...	...	·20 „
Sulphuric Acid (SO_3)		...	trace	...
				98·91

* Containing Nitrogen equal to Ammonia		...	·124 °/ₒ
Do. equal to Nitric Acid	...	...	·002 „
Extract soluble in water, salts and humus substances	... ...	...	·013 „

No. 15.—A rich, newly opened bheel soil from the same estate, nearly black in colour when wet, greyish when dry, very hygroscopic and retentive of moisture,—when moistened it had an exceedingly acid re-action, which required neutralisation with lime, either in the caustic or mild state ; the amount of matter soluble in pure water was not large, and consisted chiefly of humus acids with traces of mineral matter, but a dilute alkaline solution extracted a much larger quantity, which were precipitated from solution on acidifying. Its great retentive power was shown by its retaining considerably more than its own weight of water, even when drained with the aid of a vacuum pump. When dry this soil is richer in plant food than the cattle manure obtained in this country, and its application as top-dressing has proved very beneficial to tea bushes on worn out teela soils.

Mechanical Composition.

Fine sand and comminuted organic matter		...	24·29 °/ₒ
Sand and organic matter	...	...	18·57 „
Fragments of decomposing wood, jungle, &c.		...	57·14 „
			100·

Chemical Composition.

			Air-dried.	
Moisture	...	...	18·62 °/ₒ	...
* Organic matter and combined water			...	34·29 °/ₒ
Sand and Silicates	...	...	...	53·04 „
Soluble Silica	...	...	...	·03 „
Oxide of Iron	...	...	...	·83 „

Alumina ...	...	...	...	10·31 °/o
Lime ...	...	...	...	·07 „
Magnesia	...	..	...	·37 „
Potash ...	...	...	...	·56 „
Phosphoric Acid	...	...	...	·50 „
Sulphuric Acid	...	...	trace	...
				100·

* Containing Nitrogen equal to Ammonia	...	1·19 °/o
Ditto equal to Nitric Acid (N_2O_5)	...	·005 „
Chlorine equal to Salt (Nacl) ...	...	·002 „
Total extract soluble in water, salts and humus substances	...	·036 „

The following three analyses were made of soils taken from the same flat or lay of land as *No. 15*, but which had been planted out with tea in different years. It is possible that the original composition of the entire flat was not identical throughout, but it is a curious fact that the longer the different portions had been under tea, the less organic matter and nitrogen they contained. This loss of valuable matter from cultivation, &c., is only what would be expected when soils similar in composition to *No. 15* are opened out, as the organic matter rapidly undergoes oxidation and decomposition under the favorable conditions of temperature and rainfall prevailing in tea districts. I have seen several such soils, that had been under tea for some years, and which now have a light loamy appearance and character, but which when opened out, were dark coloured peaty bheels full of organic matter.

No. 16.—Had been under tea about five years and *Nos. 17 and 18* six years; the difference in composition of the two latter showing that the whole flat was not identical in character. As bheel soils are often used indiscrimmately as manure for teelas when in a suitable situation, it will be as well to notice specially the different quantities of nitrogen contained in them. *No. 16* would not pay to apply to tea, for manurial purposes, *Nos. 17 and 18* only if very conveniently situated, while *No. 15* would probably pay, even if it had to be carried some distance previous to application.

Chemical Composition.

	16.	17.	18.
Moisture	2·34 °/o	4·77 °/o	6·26 °/o
* Organic matter and combined water	4·21 ,,	10·81 ,,	15·40 ,,
Sand and Silicates ...	89·61 ,,	79·73 ,,	74·37 ,,
Soluble Silica (SiO_2) ...	·01 ,,	·09 ,,	·03 ,,
Oxide of Iron (Fe_2O_3) ... } Alumina (Al_2O_3) ... }	5·08 ,,	8·44 ,,	8·40 ,,
Potash (K_2O)	·27 ,,	·39 ,,	·39 ,,
Lime (CaO)	trace	trace	·03 ,,
Magnesia (MgO) ...	·11 ,,	·08 ,,	·27 ,,
Soda (Na_2O)	·21 ,,	·12 ,,	·79 ,,
Phosphoric Acid (P_2O_5) ...	·48 ,,	·34 ,,	·32 ,,
Sulphuric acid (SO_3) ...	trace	trace	trace
	99·98	100·	100·

* Containing combined Nitrogen equal to Ammonia ... ... ·164 °/o ·374 °/o ·578 °/o.

Darjeeling Soil.

No. 19.—A soil from the Kurseong Distirct, dark in colour, very hygroscopic, containing much potash mica and fragments of easily disintegrating micaceous rock. It appeared fairly suitable for tea, and from its position was naturally well drained. It is said that this class of soil is common in Darjeeling Districts, and I endeavoured to find out if there was any thing in its composition, which would in any way affect, or cause the well known Darjeeling flavour. The only marked difference observable was the comparatively large percentage of lime present, almost all Assam and Cachar soils containing a mere trace of that constituent; some Kangra Valley soils also contain a similar high proportion of lime, but further examination of other samples from Darjeeling and other hill districts showed that this proportion of lime was not universal, though it was always present in greater quantity than in soils from the other tea districts, except in one instance from the Terai, close to the hills.

Chemical Composition.

Moisture	21·55 %	...
* Organic matter and combined water ...		11·28 %
Sand and Silicates		70·33 „
Potash		2·50 „
Lime		·25 „
Magnesia	trace	...
Oxide of Iron		5·97 „
Alumina		9·27 „
Manganese		·13 „
Phosphoric Acid		·27 „
		100·

* Containing Nitrogen equal to Ammonia ... ·535 %
Ditto ditto Nitric Acid ... ·005 „

The high percentage of potash present was derived chiefly from the easily decomposable potash mica. It will be noticed that in other soils where only a trace of lime occurs, there is generally a fair proportion of magnesia, which apparently takes the place of lime to a large extent in the ash of the tea leaf, while in the above instance, there is only a trace of magnesia present, and I found that the ash of the leaves grown on this soil contained rather more lime than magnesia. The following table shows the different proportion of lime in soils of the various tea districts. In the case of the Dooars or Terai, the comparatively high percentage shown by one soil was exceptional, and owing to being at the foot of some hills containing limestone.

No. 20—**Lime in Tea Soils.** (CaO)

No. of sample	Assam.	Cachar.	Kangra.	Darjeeling.	Dooars.	Chota-Nagpore.
1	Trace.	Trace.	·38	·48	·14	·01
2	Do.	Do.	·39	·15	·30	...
3	Do.	Do.	·06	average of six samples.	(1·50)	...
4	Do.	Do.	·17		...	...
5	Do.	·19	·12		...	...
6	·10	·11	·58		...	...
7	·15	·12	...		...	...
8	·31	·05	...	...	...	...
Average	·07	·06	·29	·32	·22	·01

No. 21.—A soil from Kangra, composed almost entirely of quartz sand and mica schist, with fragments of slatey rock. It was light coloured, exceedingly dry and apparently totally unsuitable for the luxuriant growth of tea. Other soils from the same district however differed entirely from the above, some being pale reddish loams, free from stones, and in a very fine state of division, adhesive when wet and very hard when dry.

Chemical Composition.

Moisture	... ...	1·80 %
* Organic matter and combined water	...	2·39 „
Sand and Silicates	... ...	89·86 „
Soluble Silica (SiO_2)	... ...	·25 „
Oxide of Iron (Fe_2O_3) } Alumina (Al_2O_3)	... ...	2·58 „
Manganese (Mn_3O_4)	... ...	1·72 „
Lime (CaO)	... ...	·38 „
Magnesia (MgO)	trace ...	...
Potash (K_2O) } Soda (Na_2O)	... ...	·90 „
Phosphoric Acid (P_2O_5)	... ...	·12 „
Sulphuric Acid (SO_3)	trace ...	...
		100·

* Containing Nitrogen equal to Ammonia ... ·07 „

No. 22.—Soils from Kangra Valley, all of which are under tea and which show a great difference in the proportion of sand, clay, stones, &c., as is also found in China and other tea soils.

Mechanical Composition.

	a	b	c	d	e	f
Very fine earth } Impalpable matter	4·55%	58%	47%	57%	29%	68%
Sand ...	30·87 „	42 „	53 „	43 „	71 „	32 „
Stones ...	64·58 „	...	...	...	...	...
	100·	100·	100·	100·	100·	100·

None of these soils were very rich, but some were of fair quality, and with a similar climate to that of the Assam tea districts, would be capable of yielding a good outturn.

No. 23.—A soil from Chota-Nagpore Tea District. A sandy loam, coloured red by the peroxide of iron, a large quantity of which is present. It is rather poor in organic matter and nitrogen, the former being especially required in soils of these district, to render them more absorptive and retentive of moisture, as the rainfall is deficient and the plants are subjected to long periods of drought. Other constituents, except lime are present in fair amount, and the application of nitrogenous, organic manures should be beneficial.

Mechanical Composition.

Moisture	...	...	...	8·0 %
Fine earth	...	...	...	26·8 ,,
Fine sand	...	...	...	19·6 ,,
Sand ...	...	...	...	19·8 ,,
Coarse sand	...	...	...	25·8 ,,
				100·

Chemical Composition.

Moisture	...	...	...	14·11 %
* Organic matter and combined water			...	4·61 ,,
Sand and Silicates	...	...	...	68·68 ,,
Oxide of Iron (Fe_2O_3) Alumina (Al_2O_3)		..	...	11·71 ,,
Potash (K_2O)	...	...	...	·36 ,,
Magnesia (MgO)	...	...	...	·31 ,,
Lime (CaO)	...	...	...	·01 ,,
Phosphoric Acid (P_2O_5)		...	...	·21 ,,
Sulphuric Acid (SO_3)		...	trace.	...
				100·0

* Containing Nitrogen equal to Ammonia ... ·18 %

No. 24.—Other samples of soil received from the Chota-Nagpore district nearly all present the same characteristics being dry, sandy, and coloured bright red with peroxide of iron, though occasionally soils or sub-soils of a more clayey nature are met with.

Chemical Composition.

	1	2
Moisture	2·00 %	1·40 %
*Organic matter and combined water ...	4·88 „	6·36 „
Lime (CaO)	·01 „	·06 „
Magnesia (MgO)	·25 „	·29 „
Potash (K_2O) } Soda (Na_2O) }	·45 „	·40 „
Oxide of Iron (Fe_2O_3) } Alumina (Al_2O_3) } ...	10·90 „	12·00 „
Phosphoric Acid (P_2O_5)	·20 „	·18 „
Sand and Silicates	81·31 „	79·31 „
	100·0	100·
* Containing combined Nitrogen equal to Ammonia	·16 %	·21 %

No. 2 has slightly better retentive properties than *No. 1* and rather more nitrogen, but the difference is not very marked.

The main features to be noticed in all tea soils are—

1. The great deficiency of lime in almost every case.
2. The almost entire absence of sulphuric acid, or sulphates, their being present only in minute traces.
3. The constant occurrence of manganese (frequently in large proportion, but not estimated in every case), which is also always present in the ash of the tea.
4. That soils containing the highest percentage of nitrogen are most favorable for the luxuriant growth of tea.
5. That soils of rather open character with free porous sub-soils which allow the easy penetration of the roots of the tea bushes and the removal of all stagnant water, are more suitable than those of a compact clayey nature.
6. The very small quantity of salts soluble in water even in the richest soils during the rainy season, which is due, either to their being utilized by the roots of the bushes immediately on their liberation from insoluble compounds, or to their being in great part washed away by the heavy rainfall. Whichever is the case, there is no doubt that the change of the mineral constituents of plant food, from their

insoluble state in the soil, to the soluble and readily available condition, must take place very rapidly owing to the favourable conditions of warmth and moisture. Silicates especially appear to be very easily acted upon by the atmosphere, even glass, which is composed of various Silicates, undergoing a certain amount of decomposition. Most of the phosphoric acid in the soils appears to be in a very insoluble condition, and probably occurs as a basic phosphate of iron, and it has been found that the application of manures containing soluble phosphates is of great benefit to the tea plant.

Another almost invariable feature of tea soils, irrespective of district, is the presence of one or more varieties of mica, which occur as small glistening particles and which yield on decomposition supplies of potash and magnesia to the plants. It is evident that most of these soils are derived from metamorphic and volcanic rocks, such as granite, quartz, felspar, mica, mica schist, &c., which as a rule undergo very slow decomposition, so that the formation of these soils must have been spread over an enormous period. A soil derived from one of the above rocks alone would be quite unfertile, but when derived from all of them, and containing organic matter from the decay of the growth of previous years, it forms a suitable soil for the cultivation of any crop.

It must not be supposed that the chemical analysis of a soil alone will give sufficient evidence of its fertility, for it is only one of the conditions that the soil should contain a large amount of plant food, others equally or more important being ; that a certain quantity of this food should always be in an available condition, *i. e.*, soluble in water, or water containing carbonic acid ; that the soil should be deep, especially for deep rooted plants like tea ; that it should be free from poisonous mineral or organic substances ; and that its texture must be such as to admit of the ingress of air, the free passage of water, and of roots. Given all these conditions, together with a climate suitable for the growth of tea, the land may be cleared and planted without fear of failure.

The following is a report by Mr. Joseph Cripps, the well-known analyist, upon some samples of Assam soil submitted to him by one of the leading Indian Tea Companies. He says :—

" These soils appear to have been formed by the disintegration of granitic rocks, and contain but little available plant food, the insoluble silicates alone ranging from 84 to 93 per cent. of the air-dried samples.

"Lime is found in small quantities, existing either as silicate or sulphate, and in my opinion the free use of lime, either as quicklime, marl or carbonate, should be one of the first steps taken in the future management of such soils. Quicklime should only be used, however, provided it can be followed up by a liberal dressing of organic manure dung, decaying vegetable matter, or such like substance.

"Potash and phosphoric acid are also deficient. It will be noticed that the amount of oxide of iron and alumina is much greater in the soils taken at depths of 1½ to 3 feet below the surface, than in the soils marked surface, and as the iron exists as protoxide in the lower depths, lime will have a very beneficial effect, and as opportunity is afforded, I would advise that more of the sub-soil be incorporated with the surface soil by digging or deep ploughing. "This will bring up stores of phosphoric acid and potash, which are now practically unavailable.

"The tea plant, as will be seen from the appended analysis, is one which extracts from the soil very large quantities of potash and phosphoric acid, and it is to the replacing of these constituents that the attention of the grower should be directed. It would appear that phosphoric acid and potash are most necessary for the full development of the tea plant, and, unless stores are developed from the sub-soil, or their constituents are applied in the shape of manure, the soil will become exhausted, and disease of the plant a natural consequence of such exhaustion. The disease known as red spider is most likely one of the result of this exhaustion, and it must be evident that soils, robbed of nearly all their available soluble constituents can only grow plants of a delicate and languishing character.

"For a full and vigorous growth of plant, to be followed by the production of a crops of leaves, so rich in phosphoric acid, potash, and nitrogen as in tea, a regular feeding of the plant by good rich fertilizers must be absolutely necessary.

"I understand that plants which get a fair start and have plenty of fertilizing matter to draw upon are seldom attacked by red spiders or any other parasite: while, on the other hand, as soon as a plant from want of necessary supplies of food begins to languish, it becomes a prey to disease and blight.

"The appended analysis of tea will show how large is the amount of phosphoric acid and potash required for the full development of this plant:"

Composition of the ash of tea :—

Potash	39·22
Soda	·65
Magnesia	6·47
Lime	4·24
Oxide of Iron	4·38
Protoxide of Manganese ...	1·03
Phosphoric Acid	14·55
Chlorine	·81
Sulphuric Acid	Trace
Silica	4·35
Carbonic Acid	24·30
	100·00

Tea is also very rich in Nitrogen :—

Pekoe containing	6·58
Gunpowder	6·62
Souchong	6·15
Assam	5·10

A home manure manufacturer acting on the above made a manure, the basis of which is the mineral matter necessary for the vigorous growth of the tea, combined with nitrogenous salts and animal organic matter for the production by decomposition in the soil of ammoniacal and carbonaceous constituents.

The following is the guaranteed analysis of this manure :—

20	to	22	per cent.	soluble phosphate of lime.
4	„	6	„	undissolved.
3½	„	4	„	pure ammonia.
4	„	5	„	potash.

There is no doubt that as time goes on, and soils become exhausted, more and more attention will have to be given to the question of manure; but to attempt to refertilize a soil, without ascertaining first in what respeets it is deficient, is only to waste money. Therefore analysis of the soil of a garden should be carefully made before it is decided what manure to apply.

MANURES AND MANURING.

CHAPTER III.

The use of manures for "Tea" appears to have been long understood and employed by the Chinese and Japanese, manuring being the most important operation in the cultivation of tea with the latter, although in the interior of Japan, where fertilising material may be scarce and transport costly, a great extent is cropped without much being returned to the soil. But nearer the shore a large quantity of fish manure is carried and utilised especially for tea. Shoals of herring and other small fish are caught round the Northern and Eastern Coasts, mainly for manuring purposes, and brought to points where a ready purchase is made.

It is also stated that the Chinese restrict their area of tea (green ?) cultivation rigidly to the amount of manure available, their principle being, that without continuous manuring there can be no continuous harvest. Such is not the case with the Indian tea planter, who although he may value manure, does not regulate his acreage by the amount available. According to Ball (Cultivation and Manufacture of Tea), the Chinese used to water their tea bushes in dry weather with water in which rice had been washed, and manure them often with manure in a liquid state, or with the dung of silkworms. This treatment probably refers to "green" and not to "black" tea, as the Chinese generally agree that the latter is not manured, being more fragrant when unmanured. Mr. Ball states also that the cultivation of green tea differs essentially from that of the black, as the finest description named "Hyson" is cultivated on plains in a fertile soil *and manured*. This manuring is done twice a year, in the spring and autumn; and the ground weeded and turned up about the roots four times a year. The inferior Hyson teas, known to the Chinese as "Hill tea," and the common Singlo or Twankay shrubs receive no manure, beyond the grass and weeds, which twice a year are hoed up and placed about the roots to rot. Tien Hing states that the plants are manured once in the eighth moon (September), a cavity being made about the roots, into which the manure in a liquid state is poured.

According to Von Siebold, "in Japan tea plants after the first year are topped, hoed and manured, the manure being applied both in a liquid and dry state. It consists of a mixture of mustard seed and dried sardels (a kind of herring), oilcakes of the Brassica Orientalis, and other coleworts, and night soil. These manures are found by experience to be suitable to the heavy soils congenial to the tea plant, and to exercise a decided influence on the improvement of the shrub.

Manure of various kinds has also been used in the tea districts of India and Assam, but more especially in the Hill districts.

In Hazaribagh, manure is used composed of farmyard substances, *viz.*, dung, ash, sweepings, &c., carefully collected in covered pits, to which would be added layers of green leaves from the jungle; also any quantity of phosphatic manure of which the soil may be deficient is applied in December and January.

Prior to 1877 tea planters of Assam had not thought manuring a necessary item of cultivation, and no provision had been made for collecting manure as practised by the coffee planters in Ceylon, who have erected good cattle establishments for this purpose. The cattle were rarely housed, and any manure produced was exposed to the full effects of the weather, which by the end of the rainy season rendered it almost valueless.

Colonel Money speaks of manuring having been carried on with great success in Chittagong, and says he was struck with the frequency and abundance of the flushes and the strength and flavour of the tea, and that although manuring was condemned by Chinese as having a tendency to spoil the flavour of teas, it was greatly approved of by the Calcutta brokers, and the manured tea fetched high prices in the market. He speaks highly of cattle manure, saying it is not heating like horse manure, and may be applied in large quantities without any risk, the fresher applied the better.

In Kangra, cattle manure is chiefly used, and most of the planters keep herds of their own for this purpose, and also purchase as much as they can from the villagers; and according to certain village rights which they hold, employ boys to collect manure on the pasture grounds adjoining their estates. As early as 1877 the manure question had become a serious one, as the more cultivation extended, the less was available, and as the villagers began to understand its value, they raised its price. Any oilcake also, which could be obtained at a rupee a maund, was needed to feed the cattle, and was not directly available as manure ; the villagers also use cattle manure as a fuel. Manure is necessary in Kangra not only to maintain the soil in an adequate condition, but to preserve its warmth during the cold weather, which is, compared to Darjeeling, very severe.

In Darjeeling manure was always scarce, but the natives attached little or no value to it, and its price when procurable was nominal. 3,000 or 4,000 maunds are said to have been delivered on one plantation at one anna per maund.

The amount of manure beneficial to a plant, and the age at which it should first receive it were unknown questions, but it ranged from one pound of properly preserved cattle manure per plant in its second year, from seedling, to a whole basket (about fifteen seers) for a very large plant, but seven pounds is stated to have been about sufficient for mature plants of any age.

Manuring by means of a green crop has also been tried, and in the T. A., Vol. VIII, p. 272, J. R. C. writes in answer to an inquiry by the Secretary of the Dehra Doon Tea Co. regarding mustard and tea, "that the black variety is the best and cheapest, and should be sown at the rate of eight seers per acre: if sown in March, the crop would be fit to hoe in by the 21st May, and would therefore not interfere with leaf plucking. Annual sowings would have to be made. A dressing of gypsum (native sulphate of lime) powdered, and at the rate of 5 to 10 cwts. per acre, with powdered saltpetre 2 cwts. per acre to be applied when the mustard crop was two inches high, or just after hoeing the latter in, would give a good return of leaf.

A circular dealing with this subject was also issued by the Director of the Department of Land Records and Agriculture, Assam. It deals with green manuring with mustard, and its applicability to tea gardens, and advocates a trial. Without an actual trial, it is difficult to form an opinion as to the practicability of green manuring a tea garden. One of the difficulties which present itself, and which the Director also notes, is that the portion of the garden so treated would have to be left alone till the crop would be big enough to be dug into the ground. To derive the full benefit of the system the crop should be allowed to grow until it comes into flower, and should be dug into the ground before the seeds swell. A large area could not therefore be easily dealt with unless labour were very plentiful; digging in a crop requires much deeper hoeing than that ordinarily given, and in fact approaches to trenching. As this operation would be undertaken, say two months after pruning, and when the bushes would be making new growth, it seems probable that the growth would be checked, as by the treatment many of the roots would be cut, and some of the new growth might be further injured, in clearing the bushes of plants growing close to the stems. It is also difficult to say what effect on the growth of the bushes the young and vigorous crop of mustard in the land would have, and another consideration is whether the shelter thus given would cause an increase of insect pests. Without practical trial it is almost impossible to say whether, on the whole, green manuring could be done on a tea garden.

The question of manuring was one of the main points connected with the present inquiry, as it was stated that many tea estates were greatly decreasing in outturn, owing probably to the partial exhaustion of the soil; and it was decided that a series of experiments should be made under every condition of soil, position, jât, climate, &c., to determine :—

1*st*—If there was *any* manure that could be applied to tea remuneratively.

2*nd*—The most suitable manure to apply in each case under the above conditions.

3*rd*—The value of different kinds of Indian-made oilcakes.

4*th*—The possibility of increasing the outturn and quality of tea without manuring.

5*th*—The effect of different soils and manures on the quality of tea.

For the purpose of such experiments, certain gardens were selected in the Terai, Sylhet, Cachar and Assam, embracing every condition of soil, climate, &c. These experiments were to have been made on nearly thirty gardens, and although in most cases they were commenced several were given up during the first year, either owing to short labour force preventing the Managers from having the leaf from the various plots weighed separately, or from some similar cause. A few experiments were however carefully kept and records sent in, but in hardly a single instance was the printed form supplied to Managers, and containing columns for particulars affecting the experiments, filled in or returned. This reduced the possibility of drawing conclusions from the experiments, as there are so many external influences at work affecting the results, such as rainfall, jât of plant, number of vacancies in each plot, &c.

There seems to be a widespread opinion that it will never pay to apply manures to tea, because if once commenced, it will always have to be continued at intervals, or the plants will deteriorate more than ever. There is a certain amount of truth in the objection, especially in cases where forcing or highly nitrogenous special manures are applied to plants on completely worn out or very poor soils ; since this form of manure by supplying the one constituent "nitrogen" causes an increased growth, which removes a larger quantity of mineral matter from the soil, and when the nitrogen supplied is exhausted, the soil is poorer in mineral matter than it would have been had such manure not been applied at all. But most tea soils, with the exception of some teelas which have had all the surface soil removed by the washing of heavy rains, contain inexhaustible supplies of mineral plant food though not always in a readily available form, and the nitrogen given only enables the plant to take what would otherwise be practically valueless since without the increased supply of nitrogen, the plant could only utilise it in limited quantities. Of course in such cases the nitrogenous manure would have to be applied every second or third year, to maintain the increased outturn, but if it has been found to pay for itself the first year, as it should do, if the right manure is applied to the right soil, and climatic influences or blight have not counteracted its effects, the increased outturn obtained during the second and third years, would justify the expense of a further application.

Another opinion held by many planters, especially in Assam is, that manuring is not required, as the outturn of some of the oldest gardens is stated not to have diminished since the gardens were first planted from 20 to 30 years ago. This opinion is held by Dr. Berry White, who states in his lecture on the Indian Tea Industry in 1887, that manure was used to some extent both in Assam and Chittagong ; and certainly in the North-West Provinces and the Kangra Valley, but in nearly all these cases they were not virgin soils, but had been used by the ryots before to grow crops of rice and dhall. In such places ordinary farmyard manure was very useful, and he had known it to treble the crop. They did not know what might happen in the future, but he supposed some nitrogen was obtained from the atmosphere, and, at any rate, as far as the experience of the Assam Company went, instead of showing any signs of giving out, every year showed a few pounds increase. This would probably go on for the next hundred years, or perhaps two centuries. It was not the lateral roots which supplied the nutriment to the plant, they were constantly being cut about by the hoe ; it was the tap roots which went down twelve or fifteen feet into the soil which the coffee plant would never touch. That was the reason why worn out coffee plantations made admirable tea gardens.

Surgeon-General D'Renzy also stated that the soil in Upper Assam was a very rich alluvial one, without a pebble in it to a depth of some 30 feet. His impression at one time was that notwithstanding the great natural richness of the soil, its fertility might be increased by the addition of manure containing nitrogen and phosphates, and at his suggestion one of the companies made considerable experiments with manures of that character, but it was found that these artificial manures had no appreciable effect. He was convinced therefore that in Upper Assam there was no need for the application of manures.

Before the present investigation was commenced several manurial experiments appear to have been made in different tea districts, but not always with favorable results, which may have been due to various causes, as unsuitability of the manure, opposing climatic influences, method of pruning last adopted, &c.; none of them however are recorded, and usually the experiments were only made for one year.

The results of some of these experiments are given here, having been abstracted from the *Indian Tea Gazette*, and *Tropical Agriculturist*, or taken from copies of the original papers on the experiments, kindly supplied by the Agents of the gardens on which they were carried out.

Some experiments are recorded, in which six ounces of superphosphate of lime were applied, per bush, 5 feet, by 5 feet, and 60 lbs. of tea per acre were obtained. The cost of the application was Rs. 44 which would not leave satisfactory results, when the cost of making the tea is deducted.

Messrs. Begg, Dunlop and Co's. vegetable ash manure yielded an excess of 44 lbs. per acre, in two years at a cost per acre of about Rs. 26, this also would not leave a favourable balance.

Farmyard manure is said to yield good results, but if not obtainable, the experimenter states that he would rather spend money in giving extra cultivation and deeper cold weather hoeing than in artificial manures.

Mr. F. McL. Carter made some manurial experiments in 1877 with Money and Pouder's manure mixture on the Chandpore Tea Estate, Chittagong.

The manure was applied at the rate of ½ ℔ per bush, equal to 12 cwts. per acre on the 5th and 6th of July 1877, by which time eight flushes had been removed from the experimental pieces, which represents nearly 30 per cent. of the season's outturn. The increase obtained from the manured plot over a similar unmanured plot was 99 ℔ 7 oz., which is equivalent to 14 per cent. in the 10 flushes from 17th July to the 18th December, which comprised about 70 per cent. of the actual outturn. Had the manure been applied in February, doubtless the results would have been more satisfactory.

Allowing an increase of 14 per cent. on the eight flushes prior to the application of the manure, the total increase would average about a maund of tea per acre. The manure cost Rs. 105 per ton, and the total cost of application per acre was Rs. 87-6; allowing Rs. 9 per maund as the cost of manufacture, it would be necessary for the tea to sell at Rs. 1-3-3 per ℔ to cover the expenditure.

Its beneficial effects however were extended over three seasons, but unfortunately the leaf was not weighed beyond the year of application. It was observed that the weeds grew more quickly and the flushes came out earlier, and also more abundantly on the manured piece than on those next to it.

Another flat hill of very poor soil was manured with the same mixture, and the increase of yield was very marked, and the effects were apparent for about 3 years, but no accounts were kept.

Mr. McL. Carter believes that this description of plant food is too stimulating for tea, and that the bushes fall back again when the manure ceases to act, and actually yield worse than prior to its application, which proves that when once artificial manures are used, the supply must be maintained at stated intervals ever afterwards.

Why the bushes fall off subsequently is due mainly to the soil being impoverished, in consequence of the excessive and abnormal demand made upon it by the bushes in extra yield. They themselves also suffer from the latter cause. Mr. McL. Carter in December 1881 made a proposal for carrying out manurial experiments with gobur or artificial manures, including cotton seed, none of which should cost more than Rs. 50 per ton in Calcutta; and offered to co-operate with other planters in Assam, Cachar and Sylhet, who would undertake similar experiments; but the matter does not appear to have been taken up by others.

A planter in the Dehra Doon writes in 1882, that manuring in that district becomes every year a more serious question. 50 cart loads are required per acre. Most of the manure is obtained from the cattle sheds on the garden, and some is bought from the neighbouring villages. The opening of many young gardens since 1876 has not only enhanced the value of the manure, but also made it more difficult to obtain. He suggests, throwing nearly the whole of the zemindary into grazing lands, buying a large number of cattle, building large sheds, and keeping a number of carts to carry in rough grass for litter at all seasons when procurable; and that unless some such system is adopted it will be folly to go on increasing the area of the gardens.

Mr. F. McL. Carter, Chandpore Tea Estate, Chittagong, gives some results of experiments with bone-dust and castor poonac mixed and castor poonac alone. In both cases there was a very considerable increase of crop over the unmanured plot, besides improvement in the quality of the tea. The good effects lasted up to the third year, probably chiefly due to the bone-dust.

The soil was a sandy loam, with a sub-soil of ferruginous clay and sand; the climate was moist and forcing with a mean temperature of 77·0° F. The average rainfall at the station was 106·5 inches and there are heavy dews and fogs at night.

The season was unfavourable however both for quantity and quality owing to a deficient rainfall in August, one of the best leaf-producing months, and general lowness of temperature throughout the year, which makes the forcing effects of the manures more remarkable.

Twenty three flushes were gathered at intervals of 12½ days, and there were only 77 days of rest throughout the whole year.

There were three experimental plots, to two of which the manure was applied on the 20th of March, after mixing with three times its bulk of dry earth.

Mr. McL. Carter remarks that if the manures had been applied early in February the results would probably have been even more favourable.

The outturn of green leaf was as follows :—

	lbs.	oz.	lbs.		lbs.
From No. 1 plot of ¼ acre ...	628	12	=2515 p. a,	or	629 tea.
" " 2 " " " ...	825	8	=3302 "	or	825 "
" " 3 " " " ...	913	14	=3656 "	or	914 "

On comparison of plots Nos. 1 and 2 the increase of crop per acre on the latter, due to the manure, is equal to 196lbs. of tea, or 31 per cent. ; between Nos. 1 and 3, an increase on the latter of 285lbs. of tea, equal to 45⅓ per cent.

The different items for a ton of each of the manures on the garden are as follows :—

	Rs.	A.	P.
To 1 ton castor cake @ Rs. 28	28	0	0
" freight Calcutta to Chittagong @ Rs. 16-7-4 p. ton	16	7	4
" landing charges for do. @ 4 annas per bag ...	3	8	0
" transport 25 miles in boats @ 4 pie " ...	2	14	8
" transport 2 miles in carts and application @ 6 annas per cwt.	7	7	0
Total cost per ton ...	58	5	0
" " " cwt. ...	2	14	8
" " " maund ...	2	1	4
To 1 ton of bone-dust @ Rs. 55 per ton ...	55	0	0
" freight of do. @ Rs. 25 per ton ...	25	0	0
" loading charges @ 4 annas per bag ...	3	4	0
" transport in boats @ 3 annas 7 pie per bag ...	2	14	8
" transport in carts and applying same @ 6 annas per cwt.	7	7	0
Total cost per ton ...	93	9	8
" " " cwt. ...	4	10	11
" " " maund ...	3	5	6

Cost per acre.

Plot 2.—

Bonedust @ 6 cwts. per acre	... ...	28	1	0
Castor cake @ 12 ,, ,, ,,	... ...	25	0	9
Total cost of combined manure	...	63	1	9

Plot 3.—

Castor cake @ 24 cwts. per acre	... ...	70	0	0

Result per acre.

Plot 2.—

No. 1. 629lbs. tea per acre @ say 8 annas per lb.	...	314	8	0
No. 2. 825lbs. ditto ditto	...	412	8	0
In favor of latter @ 31 per cent. increase	...	98	0	0
Less cost of manure @ 18 cwts. per acre	...	63	1	9
Therefore profits per acre	...	34	14	3

Or 53·3 per cent.

Plot 3.—

No. 1. 629lbs. tea per acre @ say 8 annas per lb.	...	314	8	0
No. 3. 914lbs. ditto ditto	...	457	0	0
In favor of latter an increase of 45·3 per cent.	...	142	8	0
Less cost of manure @ 24 cwts. per acre	...	70	0	0
Therefore profits per acre	...	72	8	0

Or 103·5 per cent.

In the foregoing calculations it has been assumed that the realization of a garden's tea will average 8 annas per lb., but it is possible it might be higher, as the quality of the tea will also be improved when the ground is adequately manured ; for according to the Broker's report on the samples from the experimental plots, their value was enhanced 2 pie per lb.

On a comparison between the yield on plots 2 and 3 (the castor cake costing Rs. 6-14-6, or 11 per cent. more per acre on latter), the increase of crop over former was also 11 per cent. and the profits due to this excess equal to 107$\frac{3}{4}$ per cent., which is conclusive that notwithstanding the greater cost of the castor cake when applied at 24 cwts. per acre, it is much more remunerative than the mixed manures at 18 cwts. per acre on plot No. 2, that were less expensive.

The experiments were continued during the second season with most satisfactory results.

Mr. Carter thought that a single application of 24 cwts. per acre of castor poonac would extend its beneficial influence in the soil for nearly three years, but it would be necessary to repeat the application after that period, to prevent the bushes falling off and possibly yielding less than before any manure was applied.

Returns of Second Season.

				lbs.		lbs.	
Plot 1.—¼ acre no manure.		Yield in green leaf		796	=	796	tea p. acre.
„ *2.*	18 cwts. of mixture	do.		898	=	899	„ „
„ *3.*	24 cwts. castor cake	do.		960	=	960	„ „

Comparing the plots, No. 2 shows an increase due to manure of 103 lbs. of tea per acre, equal to 13 per cent. over plot No. 1. And No. 3 an increase of 165 lbs per acre, equal to 20¾ per cent. over plot No. 1. Whereas between Nos. 2 and 3 the latter gives an increase of 65 lbs. of tea per acre, equal to 7 per cent. only.

The profits per acre therefore are on plot No. 2 :—

	Rs.	A.	P.
Plot 1. 796 lbs. of tea @ say 8 annas	398	0	0
„ *2.* 899 ditto ditto	449	8	0
In favor of latter by 103 lbs tea @ 8 annas, less cost of manure *nil.*	51	8	0

Therefore profits per acre, in 2nd season Rs. 51 8 0 or 81·6 °/o
Profits do. 1st „ „ 34 14 6 or 55·3 „

86 6 6 or 136·9 °/o

Results from Plot No. 3.

	Rs.	A.	P.
Plot 1. 796 lbs. tea per acre @ say 8 annas per lb. ...	398	0	0
„ *3.* 961 ditto ditto ditto ...	480	8	0
	82	8	0

In favor of latter by 165 lbs. @ 8 annas, less cost of manure *nil.*

Nett profits per acre in 2nd season Rs. 82 8 0 or 117·8 %
Add ditto 1st „ „ 72 8 0 or 103·5 „

Total nett profits per acre in two seasons ... ... Rs. 155 0 0 or 221·3 „

Mr. F. McL. Carter states that the bushes showed the effect of the manures for another season.

Manuring tea with cotton seed on Chandpore Garden, Chittagong, in seasons 1882 and 1883. In these experiments there were three manured and three unmanured plots of ¼ acre each.

Plot A.—

Manured with cotton seed @ 2lbs. per bush, equal to 68 maunds per acre.

Plot B.—

Manured with cotton seed @ 3 lbs. per bush, equal to 102 maunds per acre.

Plot C.—

1 lb. of cotton seed, mixed with 5 lbs. of gobur per bush = a combination of 204 maunds per acre.

Manures applied in March 1884, to fair Assam hybrid bushes, transplanted from nurseries in 1867.

Results in yield.

		lbs.	oz.		lbs.	
Plot A.—						
Manured	¼ acre	694	8	green leaf	= 694	tea per acre.
Non-manured	,,	564	5		= 564	,,
In favor of former by		130	3		= 130	
Or an increase of 23 per cent.						

		lbs.	oz.			lbs.	
Plot B.—							
Manured	¼ acre	831	11	,,	,,	= 831	tea per acre.
Unmanured	,,	554	2	,,	,,	= 554	,,
In favor of former by		277	9			= 277	,,
Or an increase of 50 per cent.							

		lbs.	oz.	lbs.	
Plot C.—					
Manured	¼ acre	729	10	= 730	tea per acre.
Unmanured	,,	632	10	= 633	,,
In favor of former of		97	0	= 97	,,
Or an increase of 15·3 per cent.					

There was little or no increase in value of the quality of the tea, but it averaged 8 annas 5 pie per lb.

The results are estimated as follows :—

Plot A.—

	lbs.		Rs.	As.	P.	
Manured	694	tea @ say As. 8 per lb.	347	0	0	per acre.
Non-manured	564	,, ,, ,, ...	282	0	0	,,
In favor of former	130	,, ,, ,, ...	65	0	0	,,
Less actual cost of manure, freight, transport and application			47	8	0	,,
Amount in favor of manured plot ...			17	8	0	,,

Therefore the profits were 36¾ per cent. per acre.

Plot B.—

	lbs.		Rs.	A.	P,	per acre
Manured ...	831	@ anna 8 per lb. ...	415	8	0	,,
Unmanured ...	554	,, ,, 8 ,, ...	277	0	0	,,
In favor of former by	277	... ...	138	8	0	,,
Less cost of manure, &c.		... ...	71	3	0	,,
			67	5	0	,,

Therefore the profits were 94·3 per cent. per acre.

Plot C.—

	lbs.					
Manured plot ...	730	@ As. 8 per lb. ...	365	0	0	,,
Unmanured ..	633	,, ,, 8 ,, ...	316	8	0	,,
In favor of former by	97	,, ,, ...	48	8	0	,,
Less actual cost of manures, &c.		...	39	12	0	,,
Amount in favor of manured plot		...	8	12	0	,,

Therefore the profits were 22 per cent. per acre.

From the above it will be seen that Plot B, manured with 3lbs. per bush=102 mds. or about 3½ tons per acre, gave the best returns.

The foregoing experiments were carried on in 1883, the second season, without any further application of manure.

Outturn for the 2nd Season.

Plot A.—

		lbs.		lbs.	
Manured area $\frac{1}{4}$ acre ...	...	470$\frac{3}{4}$	=	471	tea per acre.
Non-manured ...	...	457	=	457	,, ,,
In favor of former by ...	...	13$\frac{3}{4}$	=	14	,, ,,
Or an increase of ...	...	3 per cent. per acre.			
Add do. 1st year ...	...	23			,, ,,
Total increase for two seasons	...	26			,, ,,

The profits therefore will be—

	lbs.				Rs.	A.	P.
Manured plot ...	471	tea per acre	@ As. 8	...	235	8	0
Non-manured ...	457	,, ,,	@ ,, 8	...	228	8	0
In favor of former by	14	,, ,,	@ ,, 8	...	7	0	0
Less cost of manure	*nil.*						
Therefore nett profits			per acre	...	7	0	0
Add profits of 1st year			,,	...	17	8	0
Total profit in 2 years				...	24	8	0

or 51$\frac{1}{2}$ per cent.

Plot B.—

	lbs.				lbs.	
Manured area $\frac{1}{4}$ acre ...	571	green leaf	=	571	tea per acre.	
Non-manured ,, ...	426$\frac{3}{4}$	,, ,,	=	427	,, ,,	
In favor of former by	144$\frac{1}{4}$	,, ,,	=	144	,, ,,	
The increase yield therefore was			...	33$\frac{3}{4}$	per cent. per acre.	
Add do. do. 1st year ...			...	50	,, ,,	
Total increased yield in two seasons				83$\frac{3}{4}$	,, ,,	

The profits therefore will be—

	lbs.			Rs.	As.	P.
Manured plot ...	671	tea per acre.	@ As. 8 ...	285	8	0
Non-manured ...	427	,, ,,	@ ,, 8 ...	213	8	0
In favor of former by	144			72	0	0
Less cost of manure	*nil.*					
Therefore nett profit per acre		...	...	72	0	0
Add profits of 1st year		...	...	67	5	0
			Rs.	139	5	0

Or an increase of 194·5 per cent.

Plot C.—

		lbs.		lbs.	
Manured area	...	500 green leaf	=	500 tea per acre.	
Non-manured	...	438 ,, ,,	=	438 ,, ,,	
In favor of former by		62	=	62 ,, ,,	
The increased yield therefore was			...	14	per cent. per acre.
Add do. do. 1st year			..	15·3	,, ,,
Total increased yield			...	29·3	,, ,,

The profits therefore will be—

		lbs.		Rs.	As.	P.
Manured plot	...	500 tea per acre @ As. 8	...	250	0	0
Non-manured	...	438 ,, ,, ,, ,, 8	...	219	0	0
In favor of former by		62 ,, ,, ,, ,,	...	31	0	0
Less cost of manure		*nil.*				
Therefore nett profit per acre		...	...	31	0	0
Add profit previous year	...	...	...	8	12	0
Total profits in 2 years		...	...	39	12	0

=100 per cent. per acre.

In the second season the increased yield of C over plot A must be attributed to the gobur not being in a soluble condition, and therefore not fit for assimilation by the rootlets of the bushes until the second year after application.

The cotton seeds were obtained fresh at Naraingunge near Dacca at 6 annas per maund, and before application were heaped in 50 or 100 maunds, moistened with cold, or better hot water, and then covered over with clods of earth to induce fermentation, with the object of destroying their vitality, which took from 5 to 8 days.

The entire charges for transport, fermentation, and application to the soil, cost 5 annas 2 pie per maund, and including the purchase money of 6 annas per maund, the total cost per maund was 11 annas 2 pie. The former charges therefore nearly equalled the original cost.

The trials with the cotton seed were not registered after the second season, but it was very noticeable that the bushes were benefited by the single application through the third year also.

These experiments show that manuring in certain cases is profitable, and that a comparatively large outlay in the first instance, as in the case of plot B. is more profitable in the end than the smaller outlay for plot A.

An expenditure of Rs. 71-3 per acre is however a serious item, when a large area needs manuring, and at the present time on many gardens, such an outlay is almost prohibitive ; but even more than this is sometimes spent per acre for bheel soiling some teelas, and has been found to yield remunerative results, though this is partly due to the good effects being continued for a period of 8 to 10 years.

In regard to the manurial experiments made in Chittagong, they have been found so successful that manuring has been continued up to the present time. It has been found however that castor cake and other manures can be more economically replaced by *artificial* manures and large quantities of these are now applied on several gardens with profitable results.

In one or two instances large sums have been expended by firms in Calcutta on the analyses of the different soils in their gardens together with the tea bush, both wood and leaves. From these analyses, which were made in England, certain manures have been formulated and mixtures made up, which have evidently yielded good results, as their application is still continued. The reason artificial manures can be applied in certain instances, cheaper than others, is because of their more concentrated condition, by which a smaller quantity is required per acre, so that a considerable saving of carriage results.

Dr. J. Campbell Brown who carefully investigated the chemistry of tea for some years, formulated a manure to supply every organic and inorganic element requisite to produce an abundant and healthy growth of the leaves of the tea plant, and to enable them to withstand drought and blight ; it was also expected to improve the quality of the tea. Each tree would require 4 oz., or if the soil is very poor 5 to 6 oz. sprinkled in a hole round the stem and covered in. The cost of the manure including freight would not exceed £3 per acre.

Experiments with this and other manures were made on the Doloo Garden in Cachar from 1873 to 1876, and the results kindly supplied by Messrs. Barry & Co. are given in the appendix. It would appear that the manure was exhausted during the first year, but with a mixture containing all the essential ingredients this is hardly probable.

Great care is necessary for drawing correct inferences from manurial experiments, as unless every circumstance affecting them is taken into account, false conclusions are very likely to be derived, either as to the beneficial or non-beneficial effect of the manures, and the experiments would be worse than useless.

Seleng.—Experiments were carried out on this garden during 1892, which in the case of certain manures showed satisfactory results.

The soils employed for the experiments were light and heavy loams, the latter requiring rather more drainage, the present drains being too far apart for the character of the soil.

On the light soil, the bushes were old, and contained a great deal of hard, useless wood, which considerably reduced their power of responding to the effects of the manures ; on the heavy soil they were slightly better, but had apparently been checked in their growth from the want of better drainage.

All the manured plots on the light soil showed a marked improvement in appearance about six weeks after the manures had been applied, and this continued throughout the season ; but a closer examination of the individual bushes showed that many had not responded to the manures in the least, although the greater number of plants had formed good wood, and yielded foliage of a rich deep green colour. The bushes that had not been affected by the manures amounted to over 15°/ₒ of the total plants, their leaves had a sickly yellow appearances, and the stems and branches were bark-bound, and in some instance covered with lichen or moss. Their unhealthiness may have been due to several causes, as want of drainage, bad soil, or cut roots, &c., but whatever the cause they are never likely to yield profitably again, and would be best removed from among the healthier bushes.

I may here mention that on many other old gardens I found that a large percentage of the bushes were of this description, which must have the effect of considerably reducing the outturn, as hardly a single shoot is plucked from them during the year, and their presence in the soil only causes useless expenditure in cultivation, while they form a home for red spider and other blights, and prevent the free circulation of air among the other better yielding bushes.

The treatment of all the plots, with the exception of the application of the manure, was the same for the whole garden as regards cultivation and plucking, so that any increase of outturn was due entirely to the manures employed, which were rape cake, superphosphate, and lime.

The plots were six in number, four of ½ acre each being on the light soil, and two of one acre each on the heavy soil, all were planted 5 feet by 5 feet with hybrid bushes.

The superphosphate was obtained from Calcutta and applied at the rate of 9 maunds per acre on June 3rd.

The lime was applied on the 2nd July at 15 maunds per acre, and the rape cake on the 14th July at 20 maunds per acre.

Light Soil.

Plot 1. ½ acre contained 9·2 per cent. of vacancies besides several non-yielding bushes; it was manured with 4½ maunds of superphosphate, 10 maunds of cake, and 7½ maunds of lime (partly slaked).

Plot 2. ½ acre contained 3·2 per cent. of vacancies and was manured with 7½ maunds of lime, and 10 maunds of rape cake.

Plot 3. ½ acre contained 5·2 per cent. of vacancies, and a large number of non-yielding bushes; it was manured with 4½ maunds of superphosphate.

Plot 4. ½ acre contained 3 per cent. of vacancies, and was unmanured.

Heavy Soil.

Plot 5. 1 acre contained 3 per cent. of vacancies, and was manured with 9 cwt. of superphosphate.

Plot 6. 1 acre contained 3 per cent. of vacancies and was unmanured.

The cost of application of the manures, including carriage from the factory to the plots, about ½ a mile were—

Superphosphate	at 9 mds. per acre	...	Rs. 0	12
Lime	at 15 " " "	...	" 1	4
Cake	at 20 " " "	...	" 1	8

The following table shows the dates of plucking, and the amount of leaf in seers obtained from each plot :—

Weight of Green Leaf in Seers.

DATE.	½ Acre. 1	½ Acre. 2	½ Acre. 3	½ Acre. 4	1 Acre. 5	1 Acre. 6
June 22nd ...	16	28½	13¾	14	33	35½
July 2nd ...	20	28	29	16	46	47
„ 11th ...	8	12	11	8	30	28
„ 16th ...	3	3	4	3	5	4
„ 25th ...	12	16	18	12	21	27
August 2nd ...	11	13	15	12	22	25
„ 10th ...	10	21	15	12	33	34
„ 18th ...	14	17	18	14	27	27
„ 24th ...	9	11	12	8	16	14
Sept. 1st ...	15	29	28	17	38	32
„ 8th ...	11	14	13	11	18	14
„ 16th ...	13	21	15	17	24	34
„ 25th ...	15	22	27	17	33	30
Oct. 5th ...	18	24	28	17	30	32
„ 12th ...	16	14	16	12	23	35
„ 20th ...	10	19	18	11	17	29
„ 31st ...	11	20	17	13	21	32
Novr. 10th ...	9	16	21	8	19	17
„ 24th ...	9	15	10	8	18	14
TOTAL ...	230	343½	328¾	230	477	510½
Or maunds per acre.	Mds. Srs. 11 20	Mds. Srs. 17 7	Mds. Srs. 16 17½	Mds. Srs. 11 20	Mds. Srs. 11 37	Mds. Srs. 12 30½
Equalised ratio calculated from number of vacancies in each plot ...	12 20	17 27	17 10	11 32	1 12	13 4

Plot 3, which was manured with superphosphate alone, improved in outturn and appearance to the greatest extent. It yielded an increase per acre over the unmanured plot. No. 4 of 5 maunds 18 seers of green leaf, equivalent to 1 maund 14½ seers of tea, taking the ratio of tea to leaf as 1 : 4, or 25 per cent.

The total cost of the manure applied to the soil was about Rs. 35 per acre, which gave an increase in the *first* year of 109 lbs. of tea. The average price obtained during the season was over one shilling per lb., which would yield a profit of about Rs. 60 per acre. The beneficial effects of the manure however judging from the improved appearance of the bushes, would probably extend over at least another year, and any increase during the second year would be almost entirely profit, the cost of manufacture, boxes, lead, and extra freight being deducted.

Plot 2, which was manured with rape cake and lime at a cost of about Rs. 65 per acre, gave an increased outturn of 117 lbs. of tea, which would yield a profit of about Rs. 23 per acre.

Plot 1. which was manured with superphosphate, rape cake and lime at a cost of about Rs. 100 per acre, gave an increased out-turn of only 14 lbs. of tea, thus showing a loss of nearly Rs. 90 per acre.

The reason plot 1 gave such a small increase was due to the very unhealthy state of the bushes, only a few undergoing any improvement in appearance, and it serves to point out the uselessness of applying expensive manures to worn out bushes of that description. Better results would no doubt have been obtained had the bushes been heavily pruned, to remove all the old wood, which was incapable of allowing a free passage of sap from the roots. But many bushes would have been destroyed had this been done, as they had not sufficient vitality to recover from the effects of such treatment. It is evident from the results of plots 1 and 2, that nitrogen was not much required in the manure, since the superphosphate alone gave better results on an adjacent plot, the increase being almost entirely due to the soluble phosphoric acid in the manure. The sulphate of lime may also have had a slight effect, as sulphuric acid was greatly deficient in the soil, the sulphur being needed to assist in the formation of the albuminoid substances in the leaf.

The use of superphosphate on the heavy soil had little or no effect during the first year, the bushes neither improving in appearance nor yielding an increased outturn. This was probably due to the plants not having sufficient drainage, the drains, which had only been opened about one year, being six nulls apart; or the effect of the drainage so recently performed may have counteracted the effects of the manure, as it is well known, that in certain cases the outturn from newly drained land is often less in the first year after drainage, though it increases again after that period.

From the analyses of the soil, which was poor in phosphoric acid, and of the ash of tea leaf, which contains a large quantity, it is evident that the tea plant must be well supplied with that constituent in an available form to enable it to yield large and rapid flushes, and this was borne out by the effect of the superphosphate on the light soil ; but from this it must not be supposed, that on all light soils superphosphate would have the same effect, though in most cases it would probably do so, since they are generally poor in that constituent, while the amount that *is* present is in a very insoluble condition, and can only with difficulty be attacked by plants.

The chief point to be observed however is the uselessness of manuring old worn out bushes of poor jât, without first removing all bark bound stems and branches, and even then it is doubtful whether the operation will be a profitable one, as there are certain classes of hybrids, which appear incapable of yielding remuneratively, even under the most favorable circumstances.

The season was not a particularly favorable one for the growth of leaf, owing to a short rainfall (the average being 83·21 inches), and a lower mean temperature than had been known for some years.

Borbam, Amgoorie, Assam.—Experiments were made on this garden on both light and heavy soils, and the following general results were obtained :—Sulphate of potash at 1½ cwt. per acre applied to aged hybrid bushes, on a sandy soil had no effect while to the same class of bushes on a clayey soil, it gave an increase of 2½ maunds of green leaf per acre.

Nitrate of potash, or saltpetre at 1½ cwt. per acre applied to the sandy soil gave an increase of 7 maunds of green leaf, while to the clayey soil, it only gave ½ maund of increase.

A mixture of crushed bones at 3 cwt, per acre and sulphate of potash 1½ cwt. per acre appliesd to the same soils, had practically no effect.

In the above experiments which were made in 1891, it will be seen that the sulphate of potash and bones gave practically no result the first year, which is partly owing to their slow action, the bones having to undergo decomposition before being available to plants. It also appears that old plants do not respond so readily to manures of this description, which must be due to the roots near the surface having become hardened and useless from frequent mutilation in hoeing, so that the manure would have to be diffused through the soil to a greater depth, before it would reach the absorbing rootlets of the plant.

The action of the saltpetre or nitrate of potash was immediate from its great solubility, which would allow of its being carried deeply into the soil by the first penetrating shower. The greater increase shown in the case of the sandy over the clay soil, was due to the former being more in want of nitrates, and to the greater facility afforded for the diffusion of the manure, through its porosity.

These experiments were continued through 1892, when it was found that the manured plots continued to show an increase over the unmanured.

The soils employed for these experiments, were a light sandy loam and a heavy clay, the bushes on the former being planted 6′ by 6′, and on the latter 4′ by 4′; on the sandy soil the bushes were pruned according to their individual merits, while on the clay they were cut to a uniform height, the latter in every case yielding a larger outturn.

Doloo Tea Garden, North Cachar.—The soil selected for these experiments was a light brown loam, about 3 feet deep, with a gravelly and pebbly sub-soil, through which the roots of the plants and water could easily penetrate. The plants (3′ by 3′) were China, 25 years of age, and which at some period had been previously manured with oil cake and cow dung. The manures tried were bone dust, sulphate of potash, oil cake, and lime, alone and in mixtures, with intervening unmanured plots for comparison. Apparently none of them had any profitable effect during the first year, which may be due to their slow action, or to the plants not requiring any manures, since they were yielding from 7¼ maunds to 8½ maunds per acre, which is a large outturn for China bushes of that age. Although the area of tea selected for the experiments had a fairly uniform appearance, the returns from the different unmanured plots, each half an acre, show that the yield varied in different portions more than a maund of tea per acre, and from my own experiments I found that this variation was due to vacancies among the bushes, and to plants which although they lived, yielded absolutely no leaf throughout the year. It was for this reason that a column was set apart in the printed form for the number of vacancies in each plot, as without this information it is impossible to draw correct conclusions from the experiments. In the present instance the number of vacancies calculated on one plot was 12 per cent., but it is doubtful whether this would correctly represent the average of the whole area under experiment.

Another series of experiments had been made on this garden from 1872 to 1876 inclusive, in which cow dung, bheel soil, oil cake, and special fertilizers were employed. The figures of these experiments are very complete, but the plots were generally very small, being less than one-fifth of an acre, so that in calculating the results per acre, any errors in weight would be greatly magnified. The special manures drawn up from the analyses of tea soils and the ash of the bushes in one or two instances apparently yielded profitable results, even though the expense of application was as high as Rs. 109-14 per acre.

Salonah Tea Company, Nowgong, Assam.—A series of experiments were made on three gardens belonging to this Company, to try the effect of single special manures, against a mixture, containing all the most important manurial constituents, and formulated from the analyses of the soils and ash of the tea plants. The manures unfortunately were only applied about the middle of June, and the experiments were concluded by the 30th of November, so that there was little time for the action of the manures to be observed, and it would be unwise to draw any definite conclusions from the results. It appears however that saltpetre, which is a quickly acting manure had in the Langleng division, an effect equal to that of the more expensive mixed manure, but the latter would have more lasting effects. This action of saltpetre (nitrate of potash) is evidently due to the nitric acid alone, and not to the potash, as the other potash manure had little or no effect on whatever soil it has been tried.

Nitrate of soda would have an equally beneficial effect, and should be obtainable at a lower rate, but it seems that its price in India is higher than saltpetre, owing to the latter being obtainable in this country, while the former has to be imported.

The figures for these and other experiments will be found in the appendix.

Object of Manuring.

Before treating of the respective values of different manures for tea, it will be necessary to point out the constituents that are most liable to require replacing in the soils, and the extent to which they occur in the leaf and wood of the tea plant.

Tea leaf is exceedingly rich in nitrogen, containing when dry from 5% to 6%, so that its annual removal from the bushes is a serious drain on the sources of nitrogen in the soil. Part of the nitrogen is however derived from the atmosphere in the form of ammonia and nitric acid, both of which are carried to the roots of the plants dissolved in rain. The quantity obtained in this way is about 1·89 lbs. as ammonia, and 4·03 lbs. as nitric acid (N_2O), per acre per annum, which only partially replaces the amount removed, this being, in the case of an outturn of 6 maunds of tea, from 24 lbs. to 28 lbs. per acre. Another portion of the nitrogen removed may have been obtained indirectly from the atmosphere, through the medium of certain organisms in the soil, which have the power of fixing free nitrogen; but this source would not be sufficient to replace all that is removed, and the soils would gradually become poorer in this important constituent, unless some means are adopted to replace it in the form of manure.

The main source of nitrogen is from the nitrogenous organic matters in the soil, which are continually undergoing slow decomposition, and so placing the nitrogen at the disposal of future plant growth.

As generally applied in manures, the nitrogen is not directly available to plants, unless it has been added in the form of nitrates, as saltpetre (nitrate of potash); but its compounds very easily undergo decomposition, and it is liberated in the form of ammonia, which under favorable circumstances, is rapidly oxidised to nitric acid, salts of which are taken up by the roots of the bushes, for the formation of the various nitrogenous organic substances, which comprise nearly 30 per cent. of the dry matter of the leaf.

It can be easily understood that when so much nitrogen is required, it must be present in the soil in comparatively large amount, and analyses have shown, that those soils containing the most nitrogen in the form of organic matter, are capable of yielding the greatest outturn of tea, though not necessarily of the highest quality.

To replace this nitrogen as it becomes diminished by continued cropping and cultivation, various forms of manures are known, the composition and relative value of which are given. They comprise oil cakes, guanos, salts of ammonia and nitric acid, cattle manure, and some of the rich peaty bheel soils. There is no better manure for tea than the latter, and its effects when applied to heavily pruned tea are in all cases exceedingly beneficial, so that on gardens or estates where such manure is available, the importation of artificial or other manure will be quite unnecessary. Certain of the oil cakes, as rape, mustard, or castor, and cattle manure, rank next as to their availability, but their effects are not so striking as in the case of bheel soil, nor are they so permanent in character. The other manures would all have to be imported into the tea districts, which considerably adds to their expense, but as they are usually of a very concentrated nature, they are the most suitable for the purpose.

The following compositions of the ash of tea wood (prunings), and of the leaf employed for manufacture, *viz.*:—two leaves and the unopened leaf bud, will show the chief mineral constituents removed from the soil, and which it is most necessary to replace.

Chemical composition of the ash of tea prunings, including leaves and wood.

		free from sand and carbon.
Moisture	4·74 °/o	7·28 °/o
Carbon	14·11 ,,	...
Sand	20·64 ,,	...
Soluble Silica	1·68 ,,	2·54 ,,
Potash	16·06 ,,	24·61 ,,
Lime	9·82 ,,	15·05 ,,
Magnesia	6·12 ,,	9·37 ,,
Manganese	1·98 ,,	3·03 ,,
Phosphoric Acid	15·24 ,,	23·35 ,,
Carbonic Acid	6·54 ,,	10·02 ,,
Iron and Alumina, &c.	3·07 ,,	4·76 ,,
	100·00	100·00

The large amount of sand is not normally present in the ash, but is due to admixture with a small quantity of soil on which the prunings were burned. The remaining figures if calculated on the ash free from sand and carbon, which it would be if properly burned, would be increased over 50°/o as given in the second column. These figures show that potash, lime, and phosphoric acid are the chief mineral constituents removed from the soil when the prunings are carried away, and it will be seen that they are also the most important in the ash of the leaf.

Chemical composition of the ash of tea wood free from leaves.

			Without sand.	
Sand ...	16·36 %			
Soluble Silica ...	2·19 ,,		2·62 %	
Oxide of Iron, Alumina	6·73 ,,		8·04 ,,	
Lime ...	12·00 ,,		14·35 ,,	
Magnesia ...	8·54 ,,		10·20 ,,	
Potash ...	18·09 ,,	— ·35 % Oxygen.	21·63 ,,	— ·43 % Oxygen.
Soda ...	3·94 ,,	= 1·61 ,, Chlorine.	4·71 ,,	= 1·94 ,, Chlorine.
Manganese ...	·35 ,,		·42 ,,	
Phosphoric Acid	16·87 ,,		20·17 ,,	
Sulphuric Acid	4·51 ,,		5·39 ,,	
Carbonic Acid	8·81 ,,		10·53 ,,	
Chlorine ...	1·61 ,,		1·94 ,,	
	99·65 ,,		99·57 ,,	

The ash or incombustible mineral matter in tea wood averages about 1%, but it varies in different parts of the same bush not only in its amount, but also in its composition. It usually contains a certain quantity of sand, especially in cases where the bushes have been grown on a sandy sloping soil, as in the Darjeeling District, its presence being due to the heavy splashing of rain, which causes particles of silica, mica, &c., to become firmly fixed in the crevices of the bark. Although tea wood only contains about 1% of ash, the amount required from the soil for the formation of one year's growth of wood, irrespective of leaves, is nearly if not quite equal to that required by the latter ; so that the annual drain on the soil is equal to twice the ash removed by the leaves employed for manufacture, *i.e.*, in the case of a yield of six maunds of tea about 63½lbs. per acre.

Again besides the annual formation of new branches, many leaves are produced which are not required for manufacture, and there is an annual root growth, which also requires a certain amount of mineral matter for its formation, so that the quantity stated before is rather below than above the actual amount required.

A six-year old China bush, which Mr. H. C. Wathen kindly sent to Calcutta from Kurseong, was found to have the following proportions when dry :—

Weight of leaves and fine branches (about 1 year and 4 months' growth) ...	...	109 grams.
Weight of main stem and branches	...	390 ,,
,, ,, roots (cleaned) ...	...	390 ,,
Total weight of dried bush ...	...	889 ,,

Equal to about 2 lbs.

It will be seen that the root growth of six years was identical with that of the main stem and branches, and the ratio would probably continue the same throughout the life of the plant.

Of course the ash contained in the wood formed above ground is only temporarily removed from the soil (unless the prunings are carried away), and is returned to the soil when the prunings are hoed in ; but in the case of the leaves utilised for manufacture, the ash is permanently removed from the soil, and unless returned in some form of manure, the soil is bound gradually to become deteriorated.

The following is the composition of China and hybrid leaf ash, also the quantity present in the leaves :—

Hybrid leaf.			China leaf.		
Fresh.	Dry.	Tea.	Fresh.	Dry.	Tea.
1·71 °/o	7·12 °/o	6·62 °/o	1·63 °/o	6·83 °/o	6·35 °/o

Chemical Composition.

	China leaf Ash.		Hybrid leaf Ash.	
Sand	1·03 °/o		·83 °/o	
Silica (SiO_2)	·73 ,,		·33 ,,	
Oxide of Iron (Fe_2O_3) ...	1·28 ,,		1·56 ,,	
Alumina (Al_2O_3)	1·00 ,,		2·63 ,,	
Lime (CaO)	7·31 ,,		8·51 ,,	
Magnesia (MgO)	8·76 ,,		7·39 ,,	
Manganese (Mn_3O_4) ...	1·64 ,,		·73 ,,	
Potash (K_2O)	38·64 ,,		38·00 ,,	
Soda (Na_2O)	·85 ,,		·96 ,,	
Phosphoric Acid (P_2O_5) ...	20·31 ,,		20·79 ,,	
Sulphuric Acid (SO_3) ...	7·50 ,,		7·37 ,,	
Carbonic Acid (CO_2) ...	10·35 ,,		9·30 ,,	
		Oxygen.		Oxygen.
Chlorine (Cl)	·60 ,,	=·13°/o	·50 ,,	=·11
	99·87		98·79	

Calculating from these figures the quantities of potash and phosphoric acid removed from an estate by the sale of 1,000 maunds of tea, it will be found that the potash is equivalent to nearly 4 tons of sulphate of potash, and the phosphoric acid to 2 tons of bones, or in other words, these quantities of sulphate of potash and bones would have to be applied to the estate per annum, to retain the proportion of potash and phosphoric acid present in the soil when the garden was first planted out.

Portions of many estates in Assam and elsewhere have now been opened for over 35 years, and there has been a constant drain on the constituents of the soil in the proportion shown in the analyses. Calculations based on an average annual outturn of six maunds per acre show, that to replace the potash and phosphoric acid removed from the soil per acre during that period, an application of about 16 cwts. of sulphate of potash, and 8½ cwts. of bones, respectively, would be required.

The application of these constituents alone however would not bring the soil back to its virgin richness, nor would the above quantities keep the plants flourishing for another 35 years without a further application, owing to the different mechanical and chemical state of the soil at the present time, to what it was when first opened out. At that time a certain amount of the constituents of plant food was in such a condition, that it could be easily taken up by the plants, and another portion only required slight chemical action of the air to reduce it to a state soluble in water. This readily available plant food has probably in many cases either been used up, or removed from the soil in drainage waters, and what remains is not so easily liberated from its compounds, but requires a longer time, and more exposure to the atmosphere to bring it into a state of solution.

The manures that can be employed for replacing the potash, phosphoric acid and lime, &c., include some of those mentioned as nitrogenous manures, together with bones, phosphatic guanos, salts of potash and lime, the composition of some of which are given.

Composition of Manures, &c.

The following analyses of cakes and fish manure obtainable in Southern India were kindly supplied by Dr. Hooper.

Two samples of Margosa Cake.

Moisture	6·08 %	9·93 %
* Organic Matter	84·50 "	83·15 "
† Ash	9·42 "	6·92 "
	100·00	100·00
* Nitrogen	5·07	5·41
† Phosphoric Acid (P_2O_5) ...	1·49	1·33

	Castor Cake.	Ground Nut Poonac.
Moisture	8·73	5·63 %
* Organic Matter	79·81 "	82·59 "
Ash	11·46 "	11·78 "
	100·00	100·00
* Nitrogen	6·66	5·75

The fish manure mentioned is manufactured on the Western Coast for estates in the Wynaad, and two samples analysed contained 7·24 % and 6·36 % of nitrogen respectively, with an average of 8·50 % of phosphoric acid (P^2O^5).

Another fish manure or guano sent to me for analysis had the following composition :—

Moisture	4·58 %
* Organic Matter	72·91 "
Ash	22·51 "
	100·00
* Containing Nitrogen equal to Ammonia ...	8·92 %

The ash of this manure had the following composition :—

Ash.		Calculated on the Guano.
Sand	13·07 %	2·96 %
†Phosphoric Acid (P_2O_5) ...	32·93 "	† 7·41 "
Lime (CaO)	27·72 "	5·47 "
Carbonate of Lime ($CaCO_3$) ...	6·04 "	1·36 "
Oxide of Iron (Fe_2O_3) ...	10·35 "	2·32 "
Potash (K_2O)	6·16 "	1·38 "
Undetermined	3·73 "	1·61 "
	100·00	22·51 Total ash.

† Equal to Tricalcic Phosphate ... ... 16·30 %

Such a manure as the above would be very valuable on estates where it could be obtained without an excessive cost for carriage; but most of the Indian tea districts are situated far from its source, and to carry large quantities of a manure of this kind for some days, either by rail or river would be almost impossible, owing to its strong smell when decomposing. It is however considerably richer than most oil cakes, both in nitrogen and phosphoric acid, and a similar manure might possibly be obtained in useful quantities from the rivers in Assam and Cachar, in the centre of the tea districts themselves, if the native fishermen could be induced to collect it. The fact of its being poor in potash is of little importance, as in almost all cases tea soils are well supplied with that constituent.

Fish manures as generally obtained often contain large quantities of sand, which not only lessens their value but adds considerably to the cost of carriage of the useful matter. If carefully manufactured they need not contain more than 2 to 3 per cent., and an allowance should be made on any manure that contains over 5 per cent.

The analysis of a fish manure by Mr. Hughes, will show how the composition and consequently the value, varies :—

Composition.

Moisture	... ...	5·24 °/o
* Organic Matter	... ...	31·18 ,,
† Phosphoric Acid	... ...	5·24 ,,
Lime	... ...	6·20 ,,
Alkaline Salts, &c.	... ...	3·37 ,,
Sand	... ...	48·77 ,,
		100·00

* Containing Nitrogen	... ...	4·01 °/o
Equal to Ammonia	... ...	4·87 ,,
† Equal to Tricalcic Phosphate	... ...	11·44 ,,

The value of this manure, calculated from the phosphates and ammonia, is :—

			Rs.	A.	P.
Phosphates ...	11·44 °/o @ As. 12 per unit	=	8	10	0
Ammonia ...	4·87 ,, @ Rs. 6 ,,	=	30	0	0
		=	38	10	0

And the other sample given above.

Phosphates ...	16·30 % @ As. 12 per unit	=	12	3	7
Ammonia ...	8·92 ,, @ Rs. 6 ,,	=	53	8	2
			65	11	9

For these two samples of manure probably the same price would be paid unless the respective analyses and values were known, although one is worth nearly double the other ; carriage also would cost the same in the both cases, and it would probably be found, that if both these manures were applied to tea, the one would show a profit and the other a loss.

A sample of bat's guano, which would make a useful manure for tea, and not be open to some of the objections to fish manure, I found to contain nitrogen equal to ammonia 12·80 per cent., phosphoric acid (P_2O_5) equal to phosphate of lime 9·36 per cent., and only about 3 per cent. of sand. The value of this as a manure is Rs. 83-11 per ton, or Rs. 3 per maund.

			Rs.	A.	P.
Ammonia	... 12·8 % @ Rs. 6 per unit	=	76	11	0
Phosphates	... 9·36 ,, @ As. 12 ,,	=	7	0	0
			83	11	0

It is a very powerful manure and care would have to be taken with its application. It should be mixed with burnt earth, ordinary soil, or even with cow manure before being applied, in order to lessen its forcing qualities; about 5 to 7 cwts. per acre of the guano would be a good dressing, and would be best given in two or three applications. Large quantities of this manure are, I believe, obtainable in the Andamans, also from different parts of India, where it occurs in caves, and old Hindu temples. A maund of bat's guano of the above composition is worth more than two maunds of the ordinary mustard or rape cake obtainable in some tea districts, so that the cost of the manure and carriage being known, it is easy to calculate which would be the more economical to apply.

Various oil cakes are obtainable in India, but only one or two kinds, such as rape or mustard, in the tea districts, and even these in very limited quantity, so that most manures of this description have to be imported, which considerably enhances the cost, owing to the great expense of carriage for long distances.

Every variety of cake has a different composition, and even the individual kinds vary among themselves, so that when purchasing a knowledge of the composition is of great importance. The value of cakes depends almost entirely on the percentage of nitrogen present, and their being nearly free from sand or other inert matter. The quantity of phosphoric acid in the ash also affects the value to a small extent, but this is usually fairly constant. Analyses of several kinds of cakes are given, together with their respective values calculated from their composition :—

Castor Cake. (Best variety, nearly white.)

Moisture	4·20 %
* Organic Matter	87·14 ,,
† Ash or Mineral Matter ...	8·66 ,,
	100·00

* Containing Nitrogen equal to Ammonia	9·18 %
Containing Phosphoric Acid P_2O_5 ...	·82 ,,
Equal to Phosphate of Lime ...	1·80 ,,

The selling price of this cake in Calcutta is Re. 1-14, and its manurial value is Rs. 2 per maund.

Ammonia 9·18 °/₀ @ Rs. 6-0 per unit	= Rs.	55	1	0	per ton.
Phosphates 1·80 ,, ,, ,, 0-12 ,,	= ,,	1	6	0	,,
	= ,,	56	7	0	
or per maund	,,	2	0	0	

Ordinary Castor Cake.

Moisture	6·0 %
* Organic Matter	88·5 ,,
† Ash	5·5 ,,
	100·0

* Containing Nitrogen equal to Ammonia	3·51 °/o
† Containing Phosphoric Acid ...	1·74 „
Equal to Phosphate of Lime ...	3·78 „

Ammonia	3·51 °/o @ Rs. 6-0 per unit	=Rs.	21	0	0	per ton.
Phosphates	3·78 „ „ „ 0-12 „	= „	2	12	0	„
		„	23	12	0	
	or per maund	„	0	14	0	

Although the value of this cake is only 14 annas per maund, the selling price in Calcutta is about Re. 1-4 per maund. The great advantage to be gained by using the best kind instead of the inferior is therefore very obvious; the supply however of the former is limited, as it is only obtained during the manufacture of the best oil, for which purpose all the seeds are hand picked.

Cocoanut Cake.

Moisture	6·40 °/o
* Organic Matter	88·08 „
† Ash	5·52 „
	100·00

* Containing Nitrogen equal to Ammonia	3·85 °/o
† Containing Phosphoric Acid ...	1·21 „
Equal to Phosphate of Lime ...	2·66 „

Value.—

Ammonia	3·85 °/o @ Rs. 6-0 per unit	=Rs.	23	1	0	p. ton.
Phosphates	2·66 „ „ „ 0-12 „	= „	2	0	0	„
		„	25	1	0	
	Value per maund	„	0	14	3	

Rape Cake.

Moisture	... ...	7·20 %
* Organic Matter	... ...	84·02 „
† Ash	... ...	8·78 „
		100·00

* Containing Nitrogen equal to Ammonia	... ...	7·82 %
† Containing Phosphoric Acid	...	2·19 „
Equal to Phosphate of Lime	...	4·81 „

The ash of rape cake however consists largely of phosphate of potash which is easily soluble in water, and therefore readily available to plants.

Ammonia	7·82 %	@ Rs. 6-0 per unit	= Rs.	46	14	0	p. ton.
Phosphates	4·81 „	„ „ 0-12 „	= „	3	9	0	„
			„	50	7	0	
		Value per maund	„	1	13	0	

Rape and mustard cakes, as they can be obtained locally in some of the tea districts, are likely to be the kinds chiefly used for manurial purposes, especially as the former is often rich in nitrogenous matter, and contains a large proportion of ash, over half of which consists of phosphate of potash, a most valuable salt for manuring the tea plant.

The following analysis of the ash of rape cake made by Mr. Eggar, is taken from Dr. Watt's Dictionary of the Economic Products of India, and shows its value as a manure.

Chemical Composition.

Sand and Silica	... ...	13·07 %
Phosphoric Acid	... ...	32·70 „
Carbonic Acid	... ...	2·15 „
Sulphuric Acid	... ...	1·62 „
Lime	... ...	8·62 „
Magnesia	... ...	14·75 „
Oxide of Iron	... ...	4·50 „
Potash	... ...	21·90 „
Soda	... ...	......
Chloride of Potassium	... ...	0·17 „
Chloride of Sodium	... ...	0·46 „
		100·00

A ton of the cake will supply 128 lbs. of mineral matter to the soil when applied as manure, a quantity four times greater than is annually removed by six maunds of tea. This quantity could in most cases be applied to the soil at a cost of about Rs. 50 per ton, or by an expenditure of Rs. 12-8 per annum, six maunds of tea could be annually removed, without the soil becoming in any way exhausted of mineral matter, while it would be considerably enriched in nitrogen.

Poppy-Cake,—from the seeds of Papaver Somniferum. This is sometimes imported into England, where however there is not much demand for it. It is rich in nitrogen and mineral matters, and from the analysis would have a manurial value slightly below that of rape cake. The following is its composition (Dr. Watts).

Water	11·0 %
Oil	14·2 ,,
* Organic Matters	62·3 ,,
Ash	12·5 ,,
	100·0
Containing Nitrogen	7·0 ,,

Niger Cake,—from the seeds of Guizotia Abyssinica, has a comparatively low manurial value as it contains only about 4 % of nitrogen, and is not likely to be used to any extent.

Cotton Seed Cakes.—These are of two kinds, "Decorticated" and "Undecorticated," the latter containing the skin or husk of the seeds. The former kind is very rich in nitrogen, containing between 7 % and 8 % of that constituent, which makes it very valuable as a manure. Its ash also contains a large proportion of potash and phosphoric acid which adds considerably to its value. At the present time cotton seed is almost entirely wasted in India, as little oil is expressed, and it should be obtainable at a very low rate. Cotton is grown to a small extent in some of the tea districts of Assam and Cachar, also in the neighbouring hills, from where a certain amount of seed should be available. It might be profitable for planters to purchase seed in large quantities, and express the oil either for sale or for use in their machinery, as it is very suitable for that purpose ; the refuse cake could then be used as a manure ; of course as it would contain all the husks of the seeds, it would not be so valuable as when decorticated, and larger quantities would be required per acre to yield the same result. It would be very suitable for application to heavy clay soils as when mixed with the surface soil, the slowly decomposing organic matter would tend to lighten it. Cotton seed can be obtained fresh at Dacca for 6 annas per maund.

Sesamum Cake.—The following is the analysis of a pure sesamum cake, made from the compressed seed of the Sesamum Indicum or Til. This is largely cultivated in India, chiefly for the oil, but the cake is also highly prized as a cattle food, and even for human consumption in times of scarcity. There are two varieties, the black seeded or Til, and the white seeded or Tili, which are usually grown with other crops. It is sown at the commencement of the rains in light soil, and when grown alone yields from 4 to 6 maunds per acre.

Composition.

Moisture	12·54°/。
* Nitrogenous Matter	38·93 ,,
Fat, starch, &c.	35·33 ,,
Phosphate of Lime ($Ca_3P_2O_8$)	5·20 ,,
Sulphate and Carbonate of Lime } ($CaSO_4$) ($CaCO_3$)	4·62 ,,
Potassium and Sodium salts	·36 ,,
Silica, &c., Oxide of Iron	3·06 ,,
	100·00

*Containing Nitrogen	6·22°/。
Equal to Ammonia	7·56 ,,

		Rs.	A.	P.	
Ammonia 7·56°/。 @ Rs. 6 per unit	=	45	6	0	per ton.
Phosphates 5·20 ,, @ As. 12 ,,	=	3	14	0	,,
		49	4	0	,,
Value per maund		1	12	0	

Its manurial value when pure is very high, but it is usually adulterated with mustard, which would probably lower it, though not to any great extent.

It can be obtained in Calcutta in limited quantity of about 160 to 200 maunds a week at Re. 1-12 per maund, its real manurial value. This is not so cheap as rape cake, which has practically the same composition, and can be obtained at the present time at Re. 1-3 per maund, so when obtainable it would be more profitable to employ the latter.

Sirgoogea cake, obtainable in the Chota-Nagpore district, contains :—

Nitrogen equal to Ammonia	... ...	6·54 °/.
Phosphoric Acid (P_2O_5)	... ...	1·81 „
Equal to Phosphate of Lime ($Ca_3P_2O_8$)	...	3·08 „

Ammonia 6·54 °/₀ @ Rs. 6 per unit ...	Rs.=	39	4	0	per ton.
Phosphates 3·08 „ @ As. 12 „ „ ...	„ =	2	5	0	„
	„	41	9	0	
Value per maund	„	1	7	0	

Currange cake, also obtainable in Chota-Nagpore, contains :—

Nitrogen equal to Ammonia	... ...	4·59 °/₀
Phosphoric Acid (P_2O)	... ...	·80 „
Equal to Phosphate of Lime ($Ca_3P_2O_8$)	...	1·70 „

Ammonia 4·59 °/₀ @ Rs. 6 0 0 per unit	= Rs.	27	8	0	p. ton.
Phosphates 1·70 „ @ Rs. 0 12 0 „ „ ...	„	1	5	0	„
	„	28	13	0	
Value per maund	„	1	0	0	

Mohwa cake, made from the seed of the Bassia Latifolia, is obtained in several parts of India, and is generally used as a food ; it has the following composition :—

Moisture	... ...	10·65 °/₀
* Organic Matter	... ...	94·20 „
Ash	... ...	5·15 „
	...	100·00

*Containing Nitrogen	... ...	2·52 °/₀
Equal to Ammonia	... ...	

As a manure it is of very little value being worth less than As. 8 a maund, but it contains much oily and starchy substances, which make it a valuable food material.

Linseed Cake.—This is sometimes used as a manure, but owing to the large percentage of oily matter contained in conjunction with other albuminoid and non-albuminoid substances, it is more suitable for feeding purposes. If produced near to any tea district, it might be profitable to utilise this cake for feeding the factory bullocks, and to apply the manure produced to the gardens, as if properly preserved from rain, it would be far more valuable than the ordinary cattle manure. Linseed cake can be obtained in Calcutta at about Rs. 2-4 per maund or Rs. 59 per ton, and has the following composition :—

	1	2
Moisture	11·01 °/o	11·7 °/o
Oil	6·33 ,,	11·4 ,,
* Albuminoids	32·94 ,,	27·0 ,,
Mucilage	35·07 ,,	34·2 ,,
Woody fibre	8·90 ,,	9·0 ,,
Ash	5·75 ,,	6·7 ,,
	100·00	100·0
*Containing Nitrogen	5·20°/o	4·3°/o
Equal to Ammonia	6·30 ,,	5·2 ,,

The manurial values of the above two samples, without considering the phosphoric acid contained in the ash, are Rs. 37-13 per ton, or Rs. 1-5 6 per maund, and Rs. 31-3 per ton, or Rs. 1.2 per maund, respectively.

Indian Linseed Cake is often very impure from admixture of foreign seeds, and the composition consequently varies. For manurial purposes, the harder any of these oil cakes are compressed in the manufacture, the better they are, as they contain less oil and more nitrogenous matter, but for feeding purposes, they should not be too hard pressed, as they are rendered very indigestible, and at the same time are not so suitable as a food, owing to their containing less oil.

Cakes appear to be most suitable manures on soils poor in organic matter, due to the fact that such soils are poorest in organic nitrogen and so require it in the manure. Light sandy soils show the effect of the application most quickly, but the results are more lasting in the heavier class of loams. All cakes before application should be thoroughly pulverised and mixed with dry sifted soil or other suitable material.

They are best applied immediately before the first hoeing of the season, so that they may be covered in at once, the mixture being broadcasted round the bushes at the rate of about 10 cwts., or 14 maunds per acre. The necessity for the cake being covered with soil at once is not owing to the liability of loss of ammonia, but to the offensive odour produced by the decomposing oil, large quantities of which are often present in locally manufactured cakes, owing to the crude machinery and method employed by the natives.

Should cakes be employed as manures in the future, and their respective manurial values be required, it would only be necessary that an estimation be made of the total nitrogen, phosphoric acid and sand, a knowledge of which would often prevent the useless expenditure of large sums of money.

Bheel Soil.—Some bheel soils are of great value as a manure for tea, since their "general" composition is often equal to, or superior to the best cattle manure.

The best kinds are those containing large quantities of organic matter, as they are usually richest in nitrogen, while the least suitable are those of a stiff clayey, or of a light sandy character.

As bheel soiling is usually an expensive operation, the cost varying from Rs. 35 to Rs. 90 per acre, according to the distance the manure has to be carried, it is advisable to know the value of the manure before applying it, as many bheel soils are not of sufficient value for use, even if situated conveniently for application.

Their value depends chiefly on the organic matter and nitrogen they contain, also on the mineral matter, which is present in fairly large quantity and in an easily available form, since it is immediately liberated from the vegetable matter on the latter's decomposition.

Bheel soil is usually applied to the soil in a fresh state, when it often contains more than its weight of water, which not only makes it very heavy for carrying any distance, but also adds uselessly to the expense of application.

Bheel soils also usually contain certain injurious soluble compounds, which can only be removed by oxidation through exposure to the atmosphere ; and if such soil were applied to tea during the rainy season, harm would probably result to the bushes, from these compounds being washed down to their roots.

As a general rule, however, bheel soiling is only performed in the dry season, so that the soil undergoes a certain amount of oxidation before the rains commence. When bheel soil or any manure is to be applied to sloping land, the surface soil should first be broken up with the hoe as roughly as possible, to prevent the washing away over the hardened crust of soluble constituents and fine peaty matter. In order to lessen the expense of carrying large quantities of wet soil up some of the steep slopes on which tea is often grown, it might be advisable to dig and stack it in small heaps some weeks before application. By this means it would be found that the soil would lose about 100 per cent. of its weight of water by evaporation, without undergoing any appreciable loss of manurial matter. This is an important consideration as a dressing of 6 inch which is frequently given, is equivalent to about 340 tons of wet soil per acre, or 120 tons of the dry soil, so that a saving in carriage of 120 tons per acre would be effected.

The following is the chemical composition of a rich bheel soil from Cachar, many of which occur in that district, but to a less extent in Assam.

The figures are calculated on the *dry* soil.
Moisture (air-dried) (18·62 °/o)

* Organic Matter and Combined Water ...	34·29 °/o
Sand and Insoluble Silicates	53·04 ,,
Soluble Silica	·03 ,,
Oxide of Iron	·83 ,,
Alumina	10·31 ,,
Lime	·07 ,,
Magnesia	·37 ,,
Potash	·56 ,,
Phosphoric Acid	·50 ,
Sulphuric Acid	trace
	100·00

* Containing combined Nitrogen equal to Ammonia	1·19 °/o
Total matter soluble in pure water	·0368 ,,
Chlorine equal to Chloride of Sodium	·002 ,,
Nitrogen equal to Nitric Acid	·0058 ,,

The amount of manurial matter supplied to a soil, when a dressing of 6 inch of bheel soil of this description is applied, is enormous, and would be equivalent to an application per acre of 17½ tons of Rape Cake, or 6 tons of Sulphate of Ammonia to supply the Nitrogen ; about 1½ tons of sulphate of potash to supply the potash, and 2½ tons of bones for the phosphoric acid. Under any circumstances manures could only be wastefully applied in such quantities, and especially to soils having an abrupt slope, and exposed to frequent heavy falls of rain as some of the teela soils of Cachar. In such cases it would be more economically applied in dressings of not more than 20 to 25 tons per acre, given at intervals of four or five years.

All bheel soils, even, when of a peaty nature, have not the same composition and value as the above, and would consequently require to be applied in rather larger quantities to yield equally beneficial results The following analysis will however probably represent the average composition of bheel soils, as they occur in the nearly flat, or slightly undulating gardens in Assam.

Chemical Composition.

Moisture	17·18 %	......
*Organic Matter and Combined Water		14·74 %
Sand and Insoluble Silica		70·10 ,,
Soluble Silicates		·94 ,,
Oxide of Iron		2·00 ,,
Alumina		9·28 ,,
Manganese		1·82 ,,
Lime		trace.
Magnesia		·24 ,,
Potash		·81 ,,
Phosphoric Acid		·07 ,,
		100·00

*Containing Nitrogen equal to Ammonia	·694 ,,
Nitrogen equal to Nitric Acid	0·015 ,,

Such a soil is poor in phosphoric acid, and if used for manurial purposes, should be supplemented by an application of bones or other phosphatic manure.

Cattle Manures.

The following is the composition of Indian cattle manure as used for fuel, the analysis having been made by Mr. Hughes.

Water (dried @ 212° F.)	7·22 °/o
Organic Matters	65·32 „
Lime	1·96 „
Potash	·63 „
Soda	trace.
Phosphoric Acid	·54 „
Magnesia, Chlorine Sulphuric Acid, &c.	5·71 „
Insoluble Silicious Matter	18·62 „
	100·00

One ton of this sun-dried manure contains about the following quantities of the more important plant food constituents.

	lbs.
Lime	43
Nitrogen	33
Potash	14
Phosphoric Acid	12
	102

When such manure is burned the nitrogen is dissipated in the air, causing a loss per ton, which would take 155 lbs. of sulphate of ammonia to replace, at a cost of about Rs. 17-12.

The richness of cattle manure depends on the quality of food given to the cattle, and on its treatment after production. Preserving it under sheds to protect it from the rain will prevent loss of any of the soluble constituents, and so render it more valuable when applied to the soil. On comparing the amount of plant food supplied by one ton of cattle manure, with the constituents removed by six maunds of tea, it will be seen that it far more than replaces them :—

Constituents removed from the soil by 6 maunds of tea.

Lime (CaO)	2·72 lbs.
Nitrogen	22·00 „
Potash (K_2O)	12·16 „
Phosphoric Acid (P_2O_5)	6·72 „

But it would be found that if only 1 ton of cattle manure was applied per acre per annum, little or no apparent result would be obtained, though the soil would never become impoverished, and the tea bushes would continue to yield, the same quantity of leaf for an unlimited period, if they were not prevented by age, blight or other cause. To obtain an increased yield, it would be necessary to apply from 10 to 20 tons per acre, the effects of which should last from three to four years, or longer, though according to the experience of many planters, the effects are not visible after the second year. It is difficult to understand how the effects can only be visible for such a short period, and it is contrary to the experience of agriculturists in any other country. The plant constituents in cattle manure are not present in immediately available condition, aud are only slowly liberated on the decomposition of the organic matter; when set free, with the exception of a portion of the lime, and the nitrogen, they are not liable to be removed from the soil by drainage, unless the soil is exceedingly sandy, and possesses little or no retentive power for plant food. The reason the effects are not longer visible, is most likely due to the method of pruning adopted one or two years after the manure has been applied. If the bushes are severely treated at that time by being cut low down, the new wood, that has been formed while the manure was in its most active state, will be removed, the growth of the roots checked, and when the plant has recovered, it will only have the slowly acting residue of the manure to assist the new growth.

Cattle manure, bheel soil, or any other manures are best applied to those bushes that are being heavily prunued, as it is at that period that the plants most require assistance to overcome the effects of the severe treatment. It will be also found that the plants can then form sound straight wood from near the ground, which will afford material to prune upon for several years to come, and none of the effects of the manure will be wasted.

The amount of manure produced on any estate can be greatly augmented by using large quantities of grass or other jungle for littering the cattle, which by keeping them dry would also improve the general health of the animals, especially during the rains. The chemical composition of the manure, if preserved from rain, would not differ much from that given above, especially if the animals were fed on artificial foods, as linseed cake, &c., while the increased amount of organic matter applied to the soil, would have a beneficial effect in assisting the decomposition of the mineral matter. Owing to the small amount of organic matter in tea soils requiring manure, it is advisable always to apply the cattle manure, in a fresh condition, whether the soil is sandy or clayey, so that the whole decomposition of the organic matter may take place in the soil itself. It should be hoed in soon after application, especially in clayey soils, which it will render more porous and open; while it diminishes the porosity of sandy soils, and improves their retentive qualities. Its action, when applied in the fresh state, will not be so rapid as when decomposed, but will be aided by the warm moist atmosphere of the tea districts.

Cattle manure unless properly preserved, is very liablé during decomposition to loss of nitrogen, its most valuable constituent. The heap assumes an alkaline reaction from the formation of ammonia, nitrous acid being also formed in small quantities, and by the reaction between these two compounds, free nitrogen is produced and given off; this loss however can be partly prevented by applying sulphate of lime, "gypsum," or kainit to the heap.

The urine of cattle has a high manurial value as it contains much urea, which is easily converted to carbonate of ammonia, and then to nitric acid; one advantage of the use of litter for the cattle would be the absorption of the urine, which is now generally allowed to run to waste. Straw and grass jungle would absorb most of it, if frequently changed, but the best material for this purpose is sawdust, which is available on many estates in large quantities, and could by this means be profitably utilized.

Any manure made in this way would have to be kept sheltered from the rain, owing to the extreme solubility of the useful contituents, and would be best applied as soon as prepared, otherwise it would lose a considerable quantity of nitrogen from partial decomposition.

If the sawdust was saturated with the urine it would have a very powerful forcing effect, and would have to be used with care. A dressing of two or three tons per acre, applied with bones, or other phosphatic manure, would prove useful in starting growth, and enable the plants to attack the less soluble manure.

Bone Manures.

Bones have already been used to a certain extent as a manure for tea, but with varying results owing to the character of the soils to which they have been applied. Up to the present time they have been chiefly employed in the form of crushed bones of various degrees of fineness, from pieces two or three inches in length, to the finest dust, the latter showing its effect soonest.

. The use of bones is chiefly to supply phosphoric acid to the plants, a constituent in which many tea soils are greatly deficient ; it occurs in raw bones as phosphate of lime ($Ca_3P_2O_8$) a compound insoluble in pure water, but slightly soluble in water containing carbonic acid in solution. The roots of plants appear however to have a special solvent power on this constituent as it occurs in bones, for fragments of bone have been found in the soil, through which roots have completely penetrated.

Crude bone dust undergoes decomposition or weathering very slowly, but steamed bone dust, from which all fatty matter has been removed by steaming, is completely decomposed during the first year.

It does not appear advantageous for bones to be applied entirely in a fine state of division, especially on rather porous sandy soils, as the effect does not last so long, possibly owing to the too rapid decomposition of the nitrogenous organic matter contained in them.

The most satisfactory results are obtained when the bones are of medium fineness, varying from dust to particles half an inch in diameter, as by this means the dust is almost immediately utilized, while the coarser particles are decomposed more gradually and slowly yield their constituents to the plant.

The following analyses are of bone meal utilized for manuring tea both samples being of equal fineness.

Moisture	... 8·38 %	7·16 %
*Organic Matter ...	... 28·19 „	27·13 „
Phosphate of Lime (Ca_3P_2O)	... 50·15 „	49·16 „
Carbonate of Lime, &c. ...	... 11·60 „	11·31 „
Sand	... 1·68 „	5·24 „
	100·00	100·00
*Containing Nitrogen equal to Ammonia	... 4·61 %	3·8 %

No. 1.

Ammonia	4·61 °/o	@ Rs. 6 per unit	=	Rs. 27-10-0	per ton.
Phosphates	50·15 ,,	@ As. 12 ,,	=	,, 37-10-0	,,
		Value per ton	=	Rs. 65-4-0	
		Value per md.	=	,, 2-5-0	

No. 2.

Ammonia	3·8 °/o	@ Rs. 6 per unit	=	Rs. 22-13-0
Phosphates	49·16 ,,	@ As. 12 ,,	=	,, 36-13-0
		Value per ton	=	Rs. 59-10-0
		Value per md.	=	,, 2-2-0

It will be seen that No. 1 was worth 3 annas per maund more than No. 2, while the prices in Calcutta were respectively for No. 1. Rs. 57 per ton, or Rs. 2-10 per maund, and for No. 2 Rs. 60 per ton, or Rs. 3 per maund.

Bone meal can be obtained in certain districts as Jalpaiguri in the Dooars at about Rs. 1-8 per maund which is considerably below its manurial value. This bone meal is prepared by the convicts, and can only be produced in limited quantities, the daily amount being only three maunds, which is utilized by planters in the district. A certain amount of bones could be collected in the different tea districts, at a very small cost, if natives of sufficiently low caste were available for the work : these could either be broken up by hand, or could be prepared by a simple process of fermentation. This is done by stacking the partially broken bones in a heap, moistening them occasionally with cattle urine and covering them with a layer of soil. In a few weeks the bones will have become softer, and can be easily broken up, before applying them to the soil. The usual quantity to apply per acre varies from 3 cwts. to 10 cwts., but as much as 20 cwts. have been applied, without however showing a profitable return in the latter case.

The effect of bones when applied to tea has been generally stated to last only two years, but if applied to the right soil in suitable quantities, the effect should last at least four or five years, and possibly longer. Bone meal is not a forcing manure, and even under the most favourable circumstances, there would be no very sudden marked change in the appearance of the bushes, but the effect is gradual and distributed over a prolonged period.

More rapid, but not such lasting effect can be obtained by the use of "superphosphate" which contains most of the phosphoric acid in a very soluble condition. It is prepared by treating bones, or mineral phosphates with sulphuric acid, which converts part of the insoluble phosphate into the soluble form, and at the same time produces a certain amount of sulphate of lime. The chemical action which takes place can be represented by the formula.

Tricalcic Phosphate.		Sulphuric Acid.		Monocalcic Phosphate.		Sulphate of Lime.
$Ca_3P_2O_8$	+	$2H_2SO_4$	=	$CaH_4P_2O_8$	+	$2CaSO_4$

which means, that two molecules of sulphuric acid act on one molecule of tricalcic phosphate, to produce one molecule of mono-calcic phosphate, and two molecules of sulphate of lime. In the ordinary process of manufacture only a portion of the insoluble phosphate is thus changed, depending on the amount of sulphuric acid employed, and the completeness of the operation. Theoretically 1 ℔. of pure sulphuric acid would be sufficient to convert rather more than 1½℔ of the insoluble phosphate to the soluble form, *i. e.*, nearly 3℔ of bones into superphosphate, but in practice owing to the presence of carbonate of lime, &c., in the bones, 32 °/o of their weight of white acid or 41 °/o of brown acid would be required.

This operation could be performed on any garden in a wooden trough or box coated with pitch to prevent the acid destroying the wood. The method would be to spread a layer of bone dust over the bottom of the box, then nearly fill it with the bones, broken into pieces an inch, or so in diameter, and finally pour in the sulphuric acid in such a manner as to moisten thoroughly all the bones ; the cover would then be placed on the box, and the mixture, with occasional stirring, allowed to remain for some hours until the reaction was complete ; care should be taken that the gases given off are not inhaled during the operation.

The mixture could then be removed, and any excess of acid dried up by adding a further quantity of fine bone dust to absorb it. After one or two months it should be powdered, and applied to the bushes at the rate of 5 to 7 cwts. per acre, according the poorness of the soil, and state of the plants. Its effect is generally rapid, the bushes in a very short time improving in appearance and outturn. This is no doubt almost entirely due to the soluble phosphoric acid, but at a later stage the sulphate of lime apparently also has a beneficial effect, by supplying lime and sulphuric acid to the plant.

The disadvantage of applying too large a dressing of superphosphate to most Indian tea soils is, that the soluble phosphoric acid, owing to the almost entire absence of lime, and presence of large quantities of iron and alumina in the soils, is soon converted into insoluble basic phosphates of those constituents, which are with great difficulty attacked by plants. It would be better therefore to apply only about 5 cwts. of well made superphosphate with 4 or 5 cwts. of bones, which would begin to take effect, as soon as the soluble phosphoric acid had been utilized or reconverted to the insoluble form.

In India, bones only are utilized for the manufacture of superphosphate, and as obtained in Calcutta, it usually contains 10 per cent. soluble calcium phosphate, equal to about 15 per cent. bone phosphate; and 15 per cent. insoluble phosphate.

Such a superphosphate can be obtained at from Rs. 3-8 to Rs. 4-8 per cwt., according to its containing more or less of the soluble phosphate.

It would be most economical always to employ the superphosphate containing practically all the phosphate in a soluble state; as carriage is very high to the tea districts, and less of the concentrated manure would be required per acre to give the same effect.

Superphosphates vary considerably in their composition, and should generally be purchased on analysis. The following is the analysis of a superphosphate made from mineral phosphate, and not from bones.

Moisture	18·88 %
Organic Matter and Combined Water	4·35 „
Monobasic Phosphate of Lime ($CaH_4P_2O_8$) ...	12·79 „
Equal to Tribasic Phosphate of Lime (bone phosphate) rendered soluble by acid ($Ca_3P_2O_8$) ...	20·04 „
Insoluble Phosphates	4·34 „
Sulphate of Lime, Alkaline Salts, &c.	55·35 „
Insoluble Siliceous Matter	4·29 „
	100·00

This would not be worth more than Rs. 51 per ton, or Rs. 1-13 per maund at the present time. It contains no nitrogen, and is therefore not so valuable a manure as a bone superphosphate, as the latter usually contains from 1 to 3 per cent. of nitrogen equal to ammonia.

When stored for any time in a damp climate, superphosphates lose in value from the reduction of part of the soluble phosphates ; this especially takes place in those made from material containing iron and alumina, as some of the mineral phosphates, but to a less extent in bones. The reduced phosphate is still available to plants to a certain extent, having a manurial value intermediate between the soluble mono-calcic and the insoluble tricalcic phosphates. It can be dissolved by an ammoniacal citrate solution, in which the tricalcic phosphate is insoluble.

Bone black or Animal Charcoal.—This manure is obtained from sugar factories, and is fairly rich in phosphates, though not in a very readily available form.

It has been found suitable for producing soluble phosphates, owing to its containing a large amount of phosphate of lime, and can also be employed for drying mineral superphosphates, or used directly as a manure. The following is an average composition :—

Moisture	... 2·59	%
Phosphate of Lime ($Ca_3P_2O_8$) ...	... 69·79	,,
Calcium and Magnesium Carbonates, &c.	... 14·89	,,
Carbon	... 6.30	,,
Sand	... 6·43	,,
	100·00	

The phosphate of lime in this manure is said to have a solubility of one part in 6,000 parts of water saturated with carbonic acid, while the same constituent in finely ground apatite has a solubility of only one part in 140,840 parts of water saturated with carbonic acid. The presence of decomposing organic matter in the soil to which it is applied, will therefore greatly assist in its solution.

It is only obtainable in India in limited quantities at about Rs. 2 per maund which is below its real manurial value : its action is slow, but should continue for 4 or 5 years, and when first applied some nitrogenous manure should be mixed with it to hasten its effects.

Basic Slag.

This is another manure for supplying phosphoric acid to plants. It is prepared in the manufacture of steel, and contains from 35 to 45 per cent. or more of phosphate of lime, part of which is in a readily available form as tetra-calcic phosphate $Ca_3P_2O_8,CaO$. It is liable to great variation in composition, and in fineness, and should always be purchased on analysis. A guarantee should also be obtained as to its state of division, it being essential, that at least 80 to 90 per cent. pass through a sieve of 10,000 meshes per sq. inch. A sample received from Messrs. Balmer, Lawrie & Co., known as Glengarnock Basic Slag, was guaranteed to contain 17 per cent. of phosphoric acid (P_2O_5), and about 50 per cent. of lime, of which 23·2 per cent. would be in the state of quick lime (CaO), and 26·8 per cent. combined with the phosphoric acid. Its price in 1890 was Rs. 28 per ton in England, so that in Calcutta it would cost about Re. 1 per unit of phosphate of lime, which is more expensive than bone meal in which the phosphate of lime costs As. 12 per unit, *i.e.*, one per cent. per ton. But the phosphoric acid is in a more readily available condition than in bones, so that a quicker return would be obtained from its use. The quantity to apply per acre would be about 10 to 15 maunds given in two or three applications, since the phosphoric acid would probably soon revert to the insoluble condition as in the case of superphosphates.

Guanos.

Peruvian guanos have been tried as manure for tea in one or two instances, but I have not seen results of the experiments. Guanos are of two kinds, "Nitrogenous" and "Phosphatic," the former supplying chiefly nitrogen, the latter phosphoric acid to the plants. Their composition is very varied, and if employed they should always be purchased on analysis. A considerable portion of the phosphoric acid in crude peruvian guano is soluble in water, large lumps of dibasic phosphate of ammonia being often found in it; part of the nitrogen also exists as nitrates. The following figures show the solubility of the phosphoric acid in different solvents:—

Total Phosphoric Acid (P_2O_5)	14·40 °/o
Phosphoric Acid Soluble in Water	6·22 ,,
,, ,, ,, ,, Citric Acid... ...	3·80 ,,
,, ,, ,, ,, Water containing Carbonic Acid ...	9·20 ,,

Guanos are very concentrated manures, and they would be best applied mixed with earth or some other inactive material, at the rate of 7 to 8 maunds per acre. If obtainable at reasonable prices, they might be employed as tea manures with advantage, since their concentrated condition makes them very suitable for being carried long distances.

The term "guano" is however often applied to other manures of very low value; one sample which was imported from England and tried on tea, containing the following constituents:—

Nitrogen combined as Ammonia (NH_3)	...	·35 %
Do. do. Nitric Acid (N_2O)	...	·005 ,,
Nitrogen as Insoluble Organic Compounds	...	3·141 ,,
		3·496 %
Phosphoric Acid (P_2O)	...	1·96 ,,

This manure proved valueless when applied to tea, and consisted chiefly of sand, oxides of iron and alumina, and organic matter.

The following analyses of three guanos from different districts are taken from Johnston and Cameron's Agricultural Chemistry and show the variability of their composition.

	Mejillones.	Ichaboe.	Penguin Island.
Water ...	8·98 %	18·60 %	26·83 %
Organic Matter, &c.	8·36 ,,	47·84 ,,	30·00 ,,
Yielding Ammonia	·75 ,,	13·00 ,,	6·60 ,,
Calie Phosphate	71·16 ,,	10·86 ,,	23·99 ,,
Calcic Carbonate	4·30 ,,	3·44 ,,	5·40 ,,
Alkaline Salts	3·34 ,,	10·90 ,,	5·45 ,,
Insoluble Matters	3·86 ,,	8·36 ,,	8·33 ,,
	100·	100·	100·

The first is merely a phosphatic mineral, and is most efficacious when converted into a superphosphate by treatment with sulphuric acid.

Their manurial values per ton, calculated from the ammonia and phosphoric acid alone on the same basis as other manures, would be Rs. 38, Rs. 86, and Rs. 58 respectively.

The Ichaboe guano, which is very rich in nitrogen, has great stimulating properties, and such a manure should only be applied in small quantities at a time, about 3 cwts. per acre, mixed with crushed bones, or other manure of less forcing character, so as to render its effects more permanent.

Most of the guanos imported into England at the present time have fallen off in quality, owing to the best sources having been exhausted, but they are still most valuable manures, more resembling the best stable and cattle manure in their complex composition than any other artificial mixture.

Wood Ashes.

On most tea estates large quantities of wood ash are obtained annually from the engines and drying machinery, and although it has a special manurial value, it has been rarely used as a manure; generally it was allowed to remain in heaps exposed to the weather, or was carried away by the garden coolies for washing purposes.

Its composition varies according to the wood from which it is derived, its freedom from sand, and the completeness to which the carbon of the wood has been burned.

A sample of wood ash contained :—

* Phosphoric Acid	P_2O_5	16·10 %
Potash	K_2O	25·20 ,,
Lime	CaO	10·00 ,,
* Equal to Tricalcic Phosphate	... ...	35·42 ,,

The remainder consisted of sand, charcoal and carbonic acid, with some iron, alumina and magnesia, which are of little manurial value.

Wood ash has been found to increase the outturn of tea bushes, when applied in large quantities, but it has no forcing qualities, and would be best applied at the rate of 5 to 7 cwts. per acre according to quality, combined with some nitrogenous manure, and mixed with dry earth or other material to insure its even distribution.

Sulphate of Potash.

This manure is obtained as a secondary product in the manufacture of nitric acid from saltpetre (nitrate of potash) and sulphuric acid. It has been tried on several gardens, but with no very beneficial effect, owing to the fact that potash is present in most tea soils in abundance, and is therefore not required as manure. It can be obtained in Calcutta at the rate of Rs. 5 per maund, or Rs. 130 per ton, and has the following composition :—

Moisture	3·63 %
Sulphate of Potash	89·74 ,,
Soda, salts, &c., undetermined	6·63 ,,
	100·

The sulphuric acid contained in it, about 39·5 per cent. can be more economically applied in superphosphates, in which it occurs as sulphate of lime.

Sulphate of potash is the chief potash salt in the manure "kainit" which contains about 25 per cent.

Nitrate of Potash, or Saltpetre.—This has been tried as a manure for tea, frequently with the best results, as an application of 2 cwts. per acre, costing when applied from Rs. 24 to Rs. 25, has caused an increased outturn of over one maund of tea during the first year, the increase apparently being continued during the second year, also. The effects of this manure however are not likely to last longer than this, and the application would have to be repeated if the full increase is to be maintained, but if the manure is applied immediately after the bushes have been heavily pruned, the sound straight wood formed during the two years will have improved the flushing qualities of the bush, so that it is not likely to fall back again for some time to its original outturn.

The price of nitrate of potash (saltpetre 95 °/₀) in Calcutta is Rs. 7 per maund, or Rs. 206 per ton, but this is liable to fluctuation. A sample analysed had the following composition :—

Moisture	2·10 °/₀
Insoluble Matter	·20 ,,
Chloride of Potash	2·86 ,,
Chloride of Sodium	1·35 ,,
Nitrate of Potash	92·83 ,,
	99·34

It is a most stimulating manure, due to the nitric acid, which is directly availabe to the bushes, being the form in which nitrogen is chiefly taken up by plants. It would be best applied in small quantities mixed with other manures as bones or superphosphates, to assist in giving a start to the bushes, and to enable them to make better use of the other manurial constituents. Tea apparently does not require all its nitrogen to be applied as nitrates, but in a form, from which it is only gradually liberated for its use, in which state it occurs in nitrogenous organic manures, as cakes, cattle manure, peaty bheels, &c.

Since in most instances, tea does not require potash as a manure, saltpetre could be replaced by nitrate of soda, if the latter was obtainable at a reasonable rate.

Pure nitrate of potash contains only 53·4 °/o of nitric acid (N_2O_5), while pure nitrate of soda contains 63·5 °/o, or a ratio of nearly 10 : 12; so that for the purpose of manuring tea, the latter, if the same price as the former, would be the more economical to apply, unless the soil was found to be poor in potash. The soda, in nitrate of soda has practically no manurial value, not because it is not required by tea, for tea utilizes a certain quantity, but because it is always present in soils in abundance.

The price of nitrate of soda in England is about £9 per ton, which with freight, and landing charges would be equivalent to Rs. 157 in Calcutta.

This is much cheaper than the saltpetre, especially when it is considered that 5 maunds of nitrate of soda are equal to 6 maunds of saltpetre, as a source of nitric acid to the plants.

Sulphate of Ammonia.—This manure has not been used to any extent for tea, and is only procurable in very limited quantity in India. It is obtained in the manufacture of coal gas, the gas liquor produced being distilled, and the ammonia received into sulphuric acid, the solution of ammonium sulphate is then evoporated until crystals begin to be formed. The commerical salt contains about 24 °/o of ammonia, and is a very stimulating manure for certain crops. It is best applied, mixed with bones or ashes, &c., at the rate of 3 to 4 cwts. per acre. The price of this manure in England is about £ 10 15*s*. per ton, which with freight and landing charges would be equivalent to Rs. 192 in Calcutta. As a manure for tea, it would be of greater benefit than nitrate of soda, as both the ammonia and sulphuric acid are required, but a free use of this would necessitate an application of lime to the soil, as it tends to cause a loss in that constituent. This is due to the fact that both the nitric acid, produced from the ammonia, and the sulphuric acid, which is set free, combine with the lime to form soluble compounds, which are easily removed by drainage. Applied in small quantities however during the growing season, very little loss would take place, as the deeper roots of the bushes would recover the salts from the drainage water; and unless the rainfall was very prolonged, the excess would again be brought to the surface by evaporation.

Sulphate of ammonia is occasionally liable to contain small quantities of sulpho-cyanide of ammonia, which is very poisonous to plants, but its presence can be easily recognised by the red colour produced, when a solution of iron in muriatic acid (HCl) is added to a strong solution of the sulphate of ammonia.

Sulphate of Iron ($FeSO_4,7H_2O$).

This has been tried as a manure for tea in small quantities, but apparently has had no very beneficial effect, all tea soils containing fair and even large quantities of iron in different stages of oxidation. It is said however to have the effect of darkening the colour of the leaves, owing probably to an increased formation of chlorophyll, and as it is the splitting up of this compound, that assists in giving the coppery colour to the leaf during manufacture, it may to a slight extent influence the value of the tea, by giving the infused leaf a better colour ; but this is a point which would require further investigation. It can be obtained in Calcutta in limited quantities at about Rs. 3 per maund ; 3 or 4 maunds would be sufficient per acre, as it is poisonous if applied in too large quantities, especially to soils poor in lime ; its chief use apparently being the production of sulphate of lime from the sulphuric acid liberated on its oxidation.

Gypsum, or Sulphate of Lime ($CaSO_4,2H_2O$).

As a waste product small quantities of sulphate of lime can be obtained from mineral water manufacturers for a nominal sum, but the supply is very limited. It can also be obtained in various parts of India, where it occurs as a mineral, but would probably not be of sufficient benefit to tea to bear the cost of carriage for long distances, and it would be cheaper to apply it as it occurs in superphosphate.

It supplies the lime and sulphuric acid removed by the tea, and the salt when in solution has a solvent effect on other mineral constituents in the soil, especially the potash occurring in felspar, which would thus be liberated for the use of the plant.

Lime or Calcium Carbonate ($CaCO_3$).

Quick Lime, Caustic Lime, or Calcium Oxide, (CaO).

Slaked Lime ($CaO,H_2O,CaCO_3$).

The use of lime as a manure for tea has proved very beneficial on a certain class of soils, *viz.*, those containing a large proportion of organic matter ; but when applied to soils poor in that substance, the visible effect is very small, notwithstanding the fact that the soils contain only a trace of lime.

On stiff clay soils after drainage, it is also very beneficial, especially when applied as quicklime, as its chemical effect is then more vigorous and active. Lime supplies a food constituent to the tea bush, which is very deficient in almost all the soils cultivated for tea. It is remarkable that tea will not only grow, but yield luxuriantly on soils, in which not more than ·1 per cent. of lime ($CaCO_3$) occurs. The ash of the leaf contains about 8·5 per cent. of its weight of that constituent, and 6 maunds of tea per acre would remove 4·85lbs., all of which has had to be collected by the roots from the soil, for which purpose they must have penetrated deeply in every direction. When however the relative weight of soil per acre to the depth of 3 feet is considered, it will be seen that ·1 per cent. indicates the presence of 8,000 to 10,000lbs. of lime, a quantity practically, inexhaustible, if only removed by tea ; but lime is the chief base lost in drainage water, especially when land is under cultivation, and manures of various kinds are applied, and it would ultimately become necessary to apply it to the soil.

The reason tea can grow well on soils so deficient in lime, is that they contain a fair proportion of magnesia, a base very similar in its properties to lime, and which can largely replace it in the vegetable economy.

The utility of applying lime to tea soils therefore lies more in its mechanical and chemical action, than as supplying plant food, and this is most marked in soils rich in organic matter, or in heavy clays. In the former class of soils, its chief action is to supply a base for neutralising the various humus acids, developed by the partial oxidation of the decomposing organic matter. Unless some such base is present, the soil will always remain in a sour unhealthy condition, and one of the most important chemical reactions in soils, *viz.*, "nitrification" is prevented. When applied to heavy soils in the form of quick lime, it should be immediately hoed in, so that its expansion on slaking, by the absorption of water, should take place entirely within the soil, which it would tend to pulverise, and make more porous.

For sandy soils, it would be best applied in the form of compost, *i.e.*, mixed with large quantities of decayed jungle or other refuse material, as when applied alone its effects are hardly visible. This compost could be easily prepared throughout the rainy season by cutting young green grass, or other jungle, and throwing it into heaps, with the admixture of certain quantities of mild lime, which would assist in its slow decomposition. A slight loss of nitrogen as ammonia might result, but if the lime used for the purpose was perfectly free from quick lime, the loss would be very trifling. The compost could be enriched by mixing with it all the wood ash, obtained from the factory, when it would have a composition not much inferior to the cattle manure produced from grass fed animals.

PLANT CONSTITUENTS.

CHAPTER IV.

These consist of fourteen elements, four of which are organic and the remaining ten, inorganic ; they include carbon, hydrogen, oxygen and nitrogen (organic elements), and potassium, sodium, calcium, magnesium, iron, manganese, silicon, sulphur, phosphorus and chlorine (inorganic elements). They are present in all plants, the great variety of which is due to their power of entering into different combinations under varying circumstances and conditions. The organic elements constitute about 95 °/₀ of the dry weight of plants, but the inorganic elements which form the other 5 °/₀ are quite as important, since without them plants could not exist.

Three of the organic elements, *viz.* :—carbon, hydrogen, and oxygen are present in almost constant proportions in all plants, but the distribution of nitrogen varies considerably, being found chiefly in the seed, as it is required for germination.

Carbon forms from 40-50 °/₀, hydrogen from 5-6 °/₀, and nitrogen from 1-2 °/₀ of the dry weight of plants ; the two former are obtained chiefly from the atmostphere as carbonic acid and water, while the latter is obtained partly from the atmosphere and partly from the soil. When absorbed by the plants they are converted into certain soluble intermediate products, and ultimately into compounds, which form the tissues and structure of the plant.

As a general rule, the essential constituents of plant food, with the exception of three or four, are present in the atmosphere and soils in abundance, and it has been found by practice and experience, that it is only necessary to supply these three or four constituents to obtain the fullest and most satisfactory results. The following table will show the constituents that are usually deficient in soils, and which, at the same time, are required in greatest abundance by most plants :—

Carbon	... 45·00	89·51 °/₀ obtained from air and rain.
Hydrogen	... 5·80	
Oxygen	... 38·71	

Soda	...	·06	1·41 % usually abundant in soils.
Magnesia	...	·50	
Oxide of Iron	...	·10	
Alumina	...	·16	
Manganese	...	·04	
Silica	...	·02	
Chlorine	...	·03	
Sulphuric Acid	...	·50	
Nitrogen	...	4·50	9·08 % usually present in soils in only limited quantity.
Phosphoric Acid	...	1·41	
Potash	...	2·59	
Lime	...	·58	

The figures given for the carbon, hydrogen, and oxygen are only approximate, having been calculated from the amount of the various organic constituents found in tea; but they agree closely with those obtained from direct ultimate analyses of other plants. The other figures given are from an analyses of the leaves of a good hybrid plant.

It is not known in what form of combination the ten mineral constituents of plants enter into the building up of organic tissues, as they can only be estimated by burning the plant, which converts into carbonates any organic acids, with which the bases may have been combined; but the forms in which they can be assimilated from the soil is well understood, from the results of long experience, and exhaustive trials. Phosphoric acid is taken up as phosphate of lime; potash as nitrate, silicate, or carbonate; and lime as carbonate, nitrate, sulphate, or phosphate.

Potash and soda, the two alkalies common in soils, have been derived chiefly from the decomposition of felspathic rocks, in which they were combined as double silicates of potash or soda and alumina; they are present in soils chiefly in the form of silicates, which are with difficulty acted upon by water, so that they are not directly available to plants. It will be seen from the above figures that potash is the most important constituent of tea, forming nearly 40 % of the mineral matter, so that its presence in an easily soluble condition is necessary to ensure healthy and rapid growth. Its decomposition and liberation from the insoluble silicates can be hastened by cultivation and exposure of the soil to the atmosphere, and is favoured by moisture and a high temperature. The quantity present in soils varies, clay soils generally being the richest in potash ; but some of the more sandy soils on which tea is largely grown, also show a high percentage on analysis, owing to the presence of a large quantity of potash mica, which is partially decomposed by the action of strong mineral acid. In these soils, however, it very slowly becomes available to plants owing to its insoluble condition, but the presence of decomposing organic matter would hasten its liberation, by keeping the soil moist, and yielding certain gases and acids, which would assist in the change.

Potash is present in fair quantity in grass lands, where the annual burning of the grass has caused an accumulation of mineral matter near the surface, and it is probably owing to this fact, that tea so frequently does well on such lands, especially during the first years of growth. Salts of potash have been tried as manure for tea, and the results of the experiments have been given in the appendix.

Potash does not stimulate any special function, but like nitrogen, phosphorus and sulphur, &c., is generally useful in the plant, probably taking part in the building up of every cell.

Lime, usually occurs in soils as carbonate, but may be present as sulphate, phosphate or silicate. It forms about 7 to 8 °/₀ of the ash of tea leaves, but does not appear to have the same importance, as in the case of some other plants. It is very deficient in almost all the tea soils I have examined, magnesia appearing to take its place, and to act as an efficient substitute. When taken up by plants it assists in the translocation of some of the intermediate products of vegetation from one part of the plant to another, and is utilised in the building up of the cell walls and fibrous tissues. As carbonate, lime is insoluble in pure water, but is soluble in water containing carbonic acid in solution, and by which it is taken up into the plant. Its presence in soils to any extent prevents sourness or acidity, by neutralising the organic acids formed, and it is also useful in aiding nitrification, by supplying a base with which the nitric acid can combine. The effect of a large proportion of lime in soils is to cause an increased fruitfulness, with diminished growth, hence soils utilised by seed growing bushes should contain more lime than those for leaf production only.

Magnesia in most tea soils predominates over lime, but it is present to a great extent in an insoluble condition as a double silicate, or "magnesia mica" which can be seen as dark shiny scales, differing from the potash mica in colour. It also occurs in soils as carbonate, but rarely in tea soils, and occasionally as a hydrated silicate or disintegrated soap-stone. In one tea soil, in which it occurred in the latter form, it was found that the tea plant would not grow during the rains, and this was probably owing to the fact that when the soil was wet, the silicate of magnesia, which was in an extremely fine state of division, set closely like a cement round the rootlets of the plants, and so prevented absorption of food and consequent growth. By some, magnesia is considered essential for the formation of chlorophyll, as it is a constant constituent of cholorophyllan, and it has been found that certain plants become blanched if magnesia is not supplied.

Iron is essential to plants, and is present in all soils in one form or another, their colours being chiefly due to the different oxides of iron. Some of the lower oxides, which give a bluish colour to soils, especially those that have been water-logged, are distinctly poisonous to some plants, and such soils have to undergo a process of oxidation before they are suitable for ordinary plant growth. Newly opened bheel soils contain the iron in the state of lower oxide, but cultivation and drainage rapidly causes its oxidation to the higher oxide, which is not poisonous to plants, and which gives to the soil a red or yellow colour.

Iron is concerned in the formation of chlorophyll, the green coloring matter of plants, but its action is not quite understood ; it has been found that the application of a small quantity of sulphate of iron to plants, causes a deepening of the green colour in a manner similar to the effect of a nitrogenous manure.

Manganese exists in soils in similar conditions but in smaller quantity than iron. It is doubtful whether its presence is essential to growth, but it is always present in fairly constant quantity in the ash of the tea plant. It has been found that manganese cannot take the place of iron in the formation of chlorophyll.

Silica occurs in all soils, both free as sand, and combined as silicates, all except the alkaline silicates being insoluble in water. The conditions of climate in the tea districts appear to be very favorable for its solution, but it is not essential to the growth of plants, though in the case of graminaceous crops, it has a beneficial effect, chiefly on account of its strengthening the tissues of the straw, a certain quantity always occurs in pure tea ash, which must have been taken up by the plant as potassium or sodium silicate.

Chlorine occurs in tea to a limited extent, being taken up from the soil as chloride of sodium or common salt. It is probably essential for certain plants, such as those that grow near the sea, as an application of salt often causes a wonderful increase in growth, especially when such plants are grown far inland. A certain amount is derived from the rain, the quantity generally decreasing with the distance from the sea. The rain in Calcutta supplies about 47 lbs. of chlorine as salt per acre per annum to the soil, but the quantity would probably be less in the tea districts, which are far removed from the coasts.

Sulphuric acid forms from 5 to 6 % of the ash of tea, but this is partly derived from the combustion of the albuminoid matter containing sulphur present in the leaf. Its presence in tea soils is especially necessary for the growth of tea, owing to the large amount of albuminoid matter "legumin" formed in the leaf, but in many instances tea soils contain the merest trace of sulphuric acid, and it is probably partly for this reason, that manures containing sulphate of lime have proved beneficial for the formation of leaf.

Phosphoric acid, is the second most important mineral constituent of tea, forming from 12 to 16 % of the ash. It is concerned largely in the formation of albuminoids, so that its presence in soil in an available condition is very essential for tea. Many tea soils do contain a large percentage of this constituent apparently as a phosphate of iron or alumina, both of which are with difficulty attacked by plants, while other soils only contain it in very limited amount ; fruitful soils are said never to contain less than ·1 to ·2 % phosphoric acid (P_2O_5). It also occurs combined with lime or magnesia, forming compounds insoluble in pure water, but soluble to a greater extent in water containing carbonic acid. Experiments have shown that its application in a soluble and therefore readily available form will on some soils yield good results.

Carbonic acid, the air in ordinary soils, according to M. Boussingault contains ·9 % carbonic acid by volume, and in manured soil 9·8 % against ·4 % in ordinary atmospheric air. Some of the carbonic acid is taken up by the roots as bicarbonate, and in solution, estimated as one-third of the total carbon necessary for the tissues.

Nitrogen is the most important organic constituent of plants to the agriculturist, because it is the only one which has to be supplied as manure, nature always affording plants an abundant supply of carbon, hydrogen and oxygen. Nitrogen occurs free in the atmosphere, of which it forms about four-fifths, and combined as ammonia and nitric acid. Numerous experiments and investigations have been made to determine whether plants had the power of utilising the free nitrogen of the air, and it has been found that certain orders of plants have that power, free nitrogen being fixed by the agency of certain bacteroids, which occur in nodules on the roots of the plants. This discovery explained why certain plants enriched the soil by their growth even when the crop was removed, the roots containing a large portion of the nitrogen stored up in the above manner, which was liberated again as ammonia on their decomposition ; this ammonia could then be utilised by other plants which had not the power of fixing free nitrogen. Certain soils also have the power of fixing free nitrogen from the air, but the chief source of nitrogen to most plants is the ammonia liberated from the decomposition of organic matter in the soil.

A certain amount of ammonia and nitric acid is also derived from the atmosphere dissolved in rain, but this rarely exceeds from 4½-5½ lbs. of nitrogen per acre per annum, notwithstanding the prevalence of thunder storms in the tropics. This amount is quite insufficient for the requirements of the tea plant, even when yielding an ordinary outturn of 5 to 6 maunds per acre, which removes about 22 lbs. of nitrogen per acre from the soil.

The nitrogen of the organic matter in soils is not directly available to plants, but has first to be converted into ammonia, and then into nitric acid before it is utilised. This change is hastened by cultivation and the presence of lime ; the conversion of the ammonia to nitric acid is due to the presence in the soil of certain nitrifying organisms, the action of which is hastened by warmth, moisture, and air.

When formed, the nitric acid combines with any base that may be present, usually lime, to form a nitrate, which being soluble in water is easily washed out of the soil, unless there is sufficient root development throughout the soil to utilize it as it is formed.

In soils rich in organic matter and exposed to the air, nitrates are slowly lost by reduction to nitrogen gas and nitrous oxide, due to the presence of numbers of vibrios similar to M. Pasteur's butyric ferment.

This loss does not take place in an atmosphere free from oxygen, consequently on peaty soils the amount of cultivation should be somewhat limited, to prevent the accession of oxygen into the soil to too great an extent.

When the nitrogen is taken up by the tea plant, it is utilised, in the formation of several nitrogenous constituents including alkaloids, albuminoids and amide bodies, which together comprise nearly one-third of the prepared tea ; and. show the great importance of this constituent as affecting the growth and production of leaf.

Nitrification chiefly takes place in the surface soil, but also slightly to a depth of 5′ or 6′ and is favoured by the presence of sulphate of lime. The amount of nitrogen as nitric acid annually obtained in soils of different depths in England is on an average of nine years :—

Soil 20″ deep, 40·2lbs. per acre, 40″ deep, 35lbs. per acre, and 60″ deep, 38·8lbs. per acre.

The nitrates are always found most abundantly in the surface soil, unless heavy rain has occurred to wash them out or down to a lower depth, from which they are again brought to the surface when evaporation sets in.

Experiments have shown that soils have the power of fixing atmospheric nitrogen by means of micro-organisms, which first take it up, and that this goes on both in soils free from vegetation, and with plants growing on them ; most being absorbed by soils having complete aeration, which assists the development of the organisms.

It has been found also that certain algae (growing on the surface of soils) have the power of fixing free atmospheric nitrogen, and the gain of nitrogen to certain soils is largely ascribed to their agency.

The loss of nitrogen that a soil undergoes is not entirely due to that removed by the growing crop, but also largely to that lost by drainage. This loss chiefly takes place when nitrification has been proceeding too rapidly for the plants to utilize the nitric acid as it is formed, and depends greatly on the mode of cultivation adopted ; it far exceeds the amount of nitrogen supplied by the rain.

The quantity of nitric acid present in tea soils at any one period varies considerably, being greatest in those soils containing a fair amount of organic matter. After a heavy rain, more is found in the subsoil than in the soil, but the reverse after a period of fine weather.

There is little likelihood of loss of nitric acid taking place in soils under tea, as the roots penetrate to a good depth, and so have greater opportunity of recovering the nitric acid from solution as it is carried down ; but if as sometimes happens, the rain falls for several consecutive days, loss is almost certain to result. Nitric acid exists, combined with lime, potash or soda, as nitrates, all of which are very soluble in water and easily washed out of the soil. It is derived partly from the atmosphere during thunder storms, but chiefly from the oxidation of the nitrogenous organic matter contained in the soil. The production of nitric acid is one of the most important chemical changes which go on in the soil, as it is chiefly in this form, that plants take up their nitrogen.

"**Humus**" is the term applied to the organic matter of soil resulting from the decay and decomposition of plants. Its constitution is variable and complicated, as it consists of a mixture of nitrogenous and non-nitrogenous constituent including several organic and vegetable acids. It is brown or black in colour depending on the amount of change and decomposition the vegetable matter has undergone.

The amount present in ordinary soils is not very great, but some bheel soils are composed largely of it; its value depends chiefly on the amount of nitrogen it contains, which nitrogen is however not directly available to plants, but has to be converted by oxidation into ammonia and nitric acid before it can be utilised.

Humus is also valuable on account of its organic carbon, and experiments with beetroots grown in soils rich and poor humus gave a marked difference in favour of the former, both as regards weight of plants and percentage of sugar. P. P. Dehérain. Compt. Rend. 109, 781—785.

The acid constituents of humus are usually combined with bases such as lime, magnesia, potash and iron, forming salts, which have a great affinity for ammonia, and so prevent the loss of that important constituent by drainage, but in newly opened bheel lands the acid constituents are to a certain extent free, and give the soil a sour and acid reaction, which would prevent the growth of any, but some stagnant-water loving plants. This acidity is destroyed to some extent by drainage and cultivation, and it can be hastened by the addition of lime or some other base to the soil.

The organic matter of peat often contains 1% or even 4% of nitrogen, resulting from the decomposition of the albuminoid and amide matter in the plants. It is present in the form of certain complicated nitrogenous bodies incapable of supplying nitrogen directly to plants, but under certain circumstances these are gradually decomposed with the conversion of the nitrogen into ammonia, and ultimately with the aid of certain micro-organisms present in the soil, into nitric acid. For this important change on which the healthy growth of plants largely depends, where manures containing nitrates are not supplied, the following conditions are most favorable.

1° a temperature ranging between 85° and 95° F.

2° the presence of moisture, about 20% in the soil.

3° the presence of limited amount of an alkaline base, with which the nascent nitric acid can combine to form a nitrate.

4° the presence of oxygen which is only to be obtained in a porous and well drained soil.

5° the presence of nitrogenous organic matter that has undergone the first stages of decomposition.

6° the presence of the nitrifying organism.

Nutrition of Plants.

The food of plants consists of carbonic acid, water and ammonia, which are obtained from the atmosphere, and certain mineral matters derived from the soil, and which have been described under the head of "soils." In order that a plant may grow, all the essential constituents must be present in soil; the absence of a single one, causing sterility, while the addition of the missing constituent to the soil by an application of manure will enable the plant to flourish.

Germination.—This process takes place best in the dark, but in the presence of atmospheric air, oxygen being absorbed, and carbonic acid evolved from the oxidation of part of the organic matter of the seed. When the seed is placed in the soil under suitable conditions of moisture, &c., some of the moisture penetrates the cell walls of the seed by endosmosis, and forms a strong solution of the contents, a kind of fermentation of the albuminoid matter of the cell having been set up by the presence of moisture and oxygen. This albuminoid matter then causes the solution of the starch, or oily matter stored up in the cells of the seed, by conversion into soluble sugar, also of the remaining albuminoid matter, by which means the cells are charged with a strong solution of sugar, albumen and salts ; endosmosis then proceeds rapidly, the water of the soil passing through the membrane of the cells and causing dilution of the contents and consequent distension, new cells are then formed, and the radicle and plumule with its leaves appear. Generally by the time the first true leaves have formed above the ground, the stored up food in the seed has become nearly exhausted ;

but now the plant is able to exist without its further aid, as by its leaves and roots, it can absorb food from the atmosphere and soil; carbonic acid, water and ammonia are absorbed and decomposed in the leaves of the plant, with the formation of new compounds, the necessary mineral matter and some of the above constituents having been absorbed from the soil at the same time. The decomposition of carbonic acid in the leaves takes place with the aid of light, in the cells containing chlorophyll (the green colouring matter of plants), but the part taken by chlorophyll in this process is not clearly understood, though it probably acts as a screen to certain rays of light. The whole process of vegetation may be looked upon as one of deoxidation, carbonic acid, the most highly oxidised carbon compound being at one end of the series of compounds, and the hydro-carbons, which contain no oxygen, at the other, the intermediate compounds that are formed having a gradually diminishing proportion of oxygen.

The whole variety of vegetable products in the vegetable cell are produced from the carbon of the carbonic acid, with varying proportions of oxygen and hydrogen from water, of nitrogen from ammonia, and of sulphur from sulphuric acid, together with phosphates, alkalies, and salts. When the carbonic acid, water and ammonia are absorbed by the leaves, the former is not completely decomposed into oxygen and carbon, but part of the oxygen is given off, and the residual compound combines at the moment of decomposition with the hydrogen of the water, or nitrogen of the ammonia, and with carbonic acid itself, to form certain new non-nitrogenous and nitrogenous compounds.

Treating first of the non-nitrogenous compounds, carbonic acid and water only are required for their formation, without the addition of ammonia. The first products formed are probably some of the least complex organic acids. As in the case of tea, tannic acid, a compound of carbon, hydrogen, and oxygen. Its chemical formula is $C_{27}H_{22}O_{17}$, and for its formation it would require 27 equivalents of carbonic acid and 22 of water, while 48 equivalents of oxygen would be separated. Boheic acid is another of the first formed products.

The next group of organic compounds formed are the neutral carbohydrates, in which further deoxidation has taken place, the hydrogen and oxygen being now in the proportion to form water. These compounds include cellulose sugar and gum, starch not being present in tea although it may possibly in minute quantity form one of the intermediate products of change. They all have the general formula $C_6H_{10}O_5$, *i.e.*, consist of 6 atoms of carbon, together with hydrogen and oxygen in the proportion to form water.

Pectine is another constituent of tea, and has nearly the same composition as the neutral carbohydrates.

The products of further deoxidation are then certain volatile oils and acids, containing an amount of oxygen less in proportion than the carbohydrates, and having a general composition similar to certain resins.

The next group formed would be certain resins, several of which are present in tea, and containing a very small amount of oxygen ; and finally the volatile essential oils consisting of carbon and hydrogen only would be produced.

Certain compounds of all the above groups are present in green tea leaf, and it can be easily understood that for all the above changes to take place a certain amount of time must be allowed. It is well known that slowly grown tea, or tea produced during rather cold weather has a better flavour and strength than that grown in the height of the season when the flushes are very rapid, and this is borne out by the analyses of the leaf. It can be seen from the above changes that such should be the case, as it is evident, the essential oil, and aromatic resinous bodies, being some of the last formed in the process of leaf growth, the longer time given has allowed of their fuller development.

Hence all the carbohydrates can be formed from the carbonic acid and water absorbed by the leaves and roots.

But besides these there are several other more complicated constituents in plants, containing in addition to the carbon, hydrogen, and oxygen, a certain amount of nitrogen, and in some also a small quantity of sulphur.

These form the nitrogenous constituents of plants and include albuminoid and amide matter, and certain alkaloids.

The nitrogen required for their formation is derived from the ammonia in the atmosphere, or from that resulting from the decomposition of organic matter in the soil, or from any nitrogenous manurial matter that may have been applied.

In some cases it is also derived from the free nitrogen of the atmosphere, which certain plants have the power of fixing and utilising, by means of bacteroids in nodules on their roots.

The first compounds formed containing nitrogen, are probably those known as amides, which are formed from ammonia by the loss of part of its hydrogen, and from vegetable acids minus part of their oxygen ; they are present to a certain extent in tea, but the quantity varies throughout the year.

Other compounds, containing carbon, hydrogen, and nitrogen, without sulphur, are also formed in plants directly from carbonic acid, water and ammonia, by a process of deoxidation, the compounds containing much less oxygen than the carbonic acid and water from which they are formed. They occur as intermediate products the result of acids or sugar acting on ammonia with deoxidation, so that their proportion in the plant is liable to variation at the different stages of growth.

These compounds include the alkaloids, such as caffeine or theine, the alkaloid of tea, and various bitter compounds, and colouring matters.

For the formation of albuminoid matter, of which there is a large quantity in tea, a certain amount of sulphur is also required, and this is derived chiefly from calcium sulphate in the soil.

Albuminoids are the most complex of all the organic products, and include albumen, fibrin, legumin or casein, &c. They contain carbon, hydrogen, nitrogen, oxygen and sulphur, together with phosphates, which latter are absolutely essential for their production and existence.

They are of very complex constitution, and although several analyses have been made, it is difficult to fix their proper chemical formula.

They vary in their chemical properties, some being coagulated by heating to a temperature below boiling water, while others remain unchanged. Others are precipitated on neutralisation of their solutions, or by the addition of certain neutral salts, or other chemical reagents. They are formed from the carbohydrates produced in the plants with the addition of ammonia and sulphuric acid, and the loss of water and oxygen, the same process of deoxidation taking place. It will thus be seen, that plants can build up from simple compounds all classes of complex organic products, as acids, carbohydrates, essential oils, resins, alkaloids and albuminoids, by one general process of deoxidation. This process of absorption and decomposition of carbonic acid with liberation of oxygen is essential for animal life, since without it, an accumulation of carbonic acid would take place in the atmosphere, resulting in time in the asphyxiation of all living beings.

From the description given of the production of the constituents of plants, it must not be imagined that changes take place consecutively, but that the various changes proceed simultaneously when once growth has commenced, and that as the various compounds are formed, further transformation to more complex bodies immediately commences, resulting in the building up of the different parts of the leaves, stems, and roots of the plants. But it must be remembered, that for all these changes to take place, the plant must be well supplied with all the mineral matter and other food necessary for its growth, and time must be allowed.

This is especially the case in respect to tea, in which the youngest shoots of the plant, where growth and change are most active, are required for the manufacture, and not the older leaves in which the chemical transformations are not so prevalent, and the contents of the cells are more fixed.

The best teas as is well known are made from bushes that have been plucked every six or seven days, as the leaves are then soft and tender, owing to the limited formation of fibrous tissue from the soluble organic products in the cells. The sap also, unless in very rainy weather, contains a larger amount of those constituents that give the body and flavour to the liquor.

The continued plucking of the young leaves and buds containing the richest and most concentrated portion of the sap of the bush, is an enormous strain on the plant, and unless it is well supplied both with organic and inorganic food, it is impossible for it to continue yielding strong and healthy flushes ; and although by the forcing effect of the climate, a succession of flushes may be produced, the juices and structure of the leaves are weak and feeble, and therefore the plants are very liable to be attacked by insects or blights, the effect of which they are unable to throw off.

Proximate Constituents of Tea.

By proximate constituents is meant, the various substances formed from the chemical elements already mentioned, and they include tannin, theine, legumin, &c., the probable mode of formation of which is described under the head of the "nutrition of plants." The following is a list of the organic constituents of which the tea leaf is composed, some of which are soluble in water either wholly or partially, while others are insoluble :—

Essential oil	·05%
Fixed oil	·50 „
Theine	4·10 „
Volatile Alkaloid	trace
Tannin	18·15 „
Boheic acid	2·34 „
Gallic acid	·83 „
Legumin	24·00 „
Albumen	1·00 „
Waxy and gummy matters	2·88 „
Pectin	12·60 „
Amides	
Cellulose fibre, &c.	21·20 „
Phlobaphene, Resins, &c.	7.85 „
Mineral matters	4·50 „
	100· „

Of the above, the most important, as affecting the quality and strength of tea, are the essential oil, theine and tannin, the other constituents affecting it according to their solubility in water. The constituents with their properties and characteristics will now be briefly described.

Essential Oil.

This constituent occurs in tea in variable, but always limited quantity, slowly grown leaves of the hybrid or China varieties generally containing the largest proportion, but even in the indigenous variety, the quantity largely increases when the growth of the leaf is partially checked either by cold, or the attack of an insect blight. Notwithstanding the small quantity usually present, it is of great importance owing to its powerful ethereal odour, to which the flavour and aroma of tea is largely due. When isolated by distillation with steam and separation from the distillate with ether, it is obtained in colourless, highly refracting, irregular shaped drops, which when exposed, gradually diffuse into the atmosphere. This explains why tea so soon loses its delicate aroma, when not protected in air-tight cases, and shows the necessity of immediate packing after manufacture.

Probably also a portion of the essential oil becomes oxidised to a resinous matter, which would not be extracted when the tea was treated with boiling water, and so the liquor would lose in flavour. Hops are known to deteriorate on keeping by such oxidation of their essential oil, and it is thought that the reason China teas will not keep, is due to a similar action. Tea oil is said not to exist in the green leaves, but to be formed during the process of oxidation in the manufacture. This however is not the case as it is present in the green leaf, although the quantity is considerably increased during the process of manufacture.

The quantity of this volatile essential oil also appears to increase during the first process of firing of the oxidised leaf, but this is probably due rather to the bursting of the interior cells of the leaf by sudden expansion of the sap, and its consequent liberation, than from any further chemical development, though possibly some chemical change also takes place, as the raw grassy smell of the wet leaf gradually gives place to the pleasant tea aroma, which is only fully developed when the leaf is perfectly dried.

There appears also to be a slight change in this constituent in the process of withering, as when properly withered, the leaf always has an aroma, closely resembling that of the oil when isolated.

Theine, or Caffeine $C_8H_{10}N_4O_2$ is the chief alkaloid occurring in tea, it is also found in Coffee, Cacao beans, Paraguay tea (Ilex Paraguayensis) and Guanana, all of which are utilised for drinking purposes in different parts of the world, on account of their refreshing properties due to this alkaloid, also in the case of Cacao to a closely related alkaloid. "Theobromine." $C_7H_8N_4O_2$.

These two alkaloids also have a close relationship with xanthine $C_5H_4N_4O_2$, a compound occasionally met with in urinary calculi, and which can be obtained artificially from muscular flesh, urine, and Guanine. By heating the crystalline lead compound of xanthine in a closed tube for some hours with one and a quarter time its weight of methyl iodide, a yellow coloured crystalline powder is obtained, (after separation of the lead with sulphuretted hydrogen), having the properties and composition of Theobromine or di-methyl xanthine, and this compound by further treatment is converted into Caffeine or tri-methyl xanthine.

Liebig was of opinion that tea contained Theobromine besides Theine, but this point even now has not been settled conclusively. Messrs. Paul and Cownley of London, in their estimations of the latter alkaloid have endeavoured for a long time to trace the presence of theobromine, but with negative results possibly owing to the small quantity of tea used for the analysis. Later analyses when larger quantities (200 grams) of tea were employed, have shown the presence of a very small quantity of a yellow and apparently amorphous alkaloid, which is almost insoluble in hot water and easily soluble in Ether, the latter proving it to be neither Theine or Theobromine.

Theine forms fine white needle shaped crystals of a silky lustre, soluble in water, alcohol, Ether, Chloroform, and Benzene, and can be separated from Theobromine by taking advantage of their different solubilities in cold Benzene. The crystals are bitter, fusible and volatile, and can be obtained perfectly pure by volatilization.

It apparently undergoes no change during the process of manufacture of tea, or in the roasting of Coffee, there being the same amount when calculated on the dry matter of the leaf or berry, both before and after manufacture.

The amount of Theine is not a constant quantity in tea, but varies in Indian and Ceylon teas from 3·22 to 4·66 % on the ordinary air dry tea.

Many analyses have been made to determine whether the value of tea was in any direct ratio to the percentage of Theine contained in it M. Burker of the Paris Society of Pharmacy, who has studied the chemistry and analysis of tea, and gone into the matter with various tea merchants, thought it pretty well established that the commercial value of black tea is in direct proportion to the amount of Theine contained in the sample analysed, while in the case of green tea the test does not answer, the question to be studied being rather the amount of tannin. Messrs. Paul and Cownley, however, find that this test is not to be depended on to any great extent, however important the constituent may be in other respects. Under the present system tea is valued by its appearance, flavour, and strength, also the colour of the infused leaves after treatment with hot water, so that the presence of slightly varying quantities of Theine, which would not add to the strength or colour of the liquor, but merely increase to a small extent the bitterness produced by the tannin, would not effect its commercial value to an appreciable extent ; at the same time the tea with the higher percentage of Theine would have a greater beneficial effect on the human system, only this fact is not regarded.

The best method for the estimation of Theine is to moisten a few grams of finely powdered tea with hot water, well mix with one-fifth of its weight of hydrate of lime, and dry on a water bath. Transfer the dried residue to a small percolator and extract with strong Alcohol. Evaporate the clear liquor to remove alcohol, and the remaining water solution mix with a few drops of dilute sulphuric acid, which separates a trace of lime and partially decolourises the liquid, filter the slightly acid solution, transfer to a separator and shake with chloroform five or six times in separate portions, until a drop of the solution on evaporation leaves no residue. Place all the chloroform solution in a stoppered separator, and shake with a very dilute solution of caustic soda, which will remove a small quantity of colouring matter, and render the Theine solution quite colourless: distil off the chloroform from a weighed flask, when the Theine should be left perfectly white. Chloroform is the best solvent for Theine, but the alkaloid does not crystallize from it so well as from alcohol or ether.

In the ordinary method of infusing tea for five minutes about 50 % of the total alkaloid present in the leaf is extracted, the other half remaining in the leaf together with the greater part of the tannin, legumin, and pectin substances.

By the old methods of analysis the results obtained for Theine were always too low, being frequently under 1 %, but by improved methods it has been found that Indian teas frequently contain over 4 %.

According to Messrs. Paul and Cownley the amount of Theine in ordinary grocer's tea (probably mixtures of Chinese and Indian teas) varies from 2·93 % to 3·93 %.

In China tea from ...	... 2·42	to	3·78	%
In Japan Congou from	... 2·60	to	2·93	„
In Java Pekoe and Souchong from	3·16	to	4·10	„

Chinese and Japanese teas appear to be generally inferior in the Theine they contain to Indian or Ceylon teas, Java tea on the other hand approaches nearer to Ceylon tea in this respect.

Tea hair, the fine downy covering so well seen on the youngest leaves and unopened leaf buds, has been found to contain 2·5°/ₒ of theine, but its presence in tea hair has also been ascribed to the small particles of parenchymatous tissue, attached to the base of the hairs.

Large quantities of this hair, which gives to the young tips their silvery or golden appearance, are lost during the manufacture, especially during the sifting and sorting processes, and it might be found profitable to obtain the alkaloid from this and other tea dust, by adopting some simple method of sublimation, by which it could be obtained pure.

The current price of Theine or Caffeine as it is generally known was a short time ago Rs. 15 per ℔, or in Germany 30 marks per kilo. This Theine is obtained from damaged or waste tea from which the duty has been removed, certain precautions being taken that it should not enter into consumption, by denaturising it with 100 ℔s of lime and 1 ℔ of assafœtida per 1,000 ℔s of tea.

English competition has reduced its price so much that it cannot now be produced in Germany. Several salts of this alkaloid are used medicinally.

Tannin or Tannic Acid $C_{27}H_{22}O_{17}$.

It is this constituent which chiefly affects the strength and pungency of tea, and is found in greatest quantity in free growing plants of this species.

Tannins are very numerous, and vary greatly both in their chemical composition and properties. More than one variety frequently occurs in the same plants, perhaps having some characters in common, but varying in their reactions with the chemical which may be used for their estimation.

In the case of tea, the tannin has usually been described as being similar to Gallotannic Acid, but it is probable another variety exists in conjunction with it.

They derive their name from one of their generally known properties of tanning animal membranes, or converting them into a durable compound called leather ; they also have the property of forming with glue, compounds more or less soluble in water. They have a slightly acid reaction, and astringent but not acid taste, they form deep blue or green, sometimes brown compounds with salts of iron, by which property they are usually distinguished from each other as iron blueing or iron greening tannic acids, the latter variety occasionally lacking the property of precipitating glue.

The colours produced with iron salts, however, often vary even with the same tannic acid, being influenced by the state of oxidation, and nature of the acid constituent of the iron salt, also by the concentration of the liquids. The tannic acids of tea gave a blue black colour and precipitate with a solution of perchloride of iron and a stale solution of sulphate of iron, and a bright blue colour, when a crystal of sulphate of iron was placed in its solution. They are precipitated by a solution of acetate of lead; when separated from lead they are brown, amorphous, with a bitter astringent taste, insoluble in ether and petroleum ether, slightly soluble in absolute alcohol, easily in dilute alcohol and cold water, and precipitate gelatine at once. With legumin, the chief albuminoid substance in tea, they also form a compound insoluble in hot and cold water, but soluble in dilute alkaline solution. A solution of tea when allowed to stand for some days, gradually loses its astringency owing to a portion of the tannic acid undergoing chemical change from the absorption of oxygen, with the formation of insoluble phlobaphenes. This change would go on in imperfectly dried leaf, and the mellowing of tea when kept for a long period is probably due to this, especially, as it is seen from analyses of Indian teas made in England, that the average percentage of tannic acid present is less than that found in freshly made tea in this country.

The moisture in the leaf, which would assist in effecting this change is almost entirely hygroscopic, that is, it has been absorbed from the atmosphere after the final firing, owing to the extremely hygroscopic nature of some of the constituents of tea. Tannic acid, when isolated pure from the leaf and perfectly dried, if exposed to the atmosphere, especially such an one as is found in Indian Tea districts during the manufacturing season, rapidly absorbs moisture becoming almost damp to the touch, a property even still more evident in the boheic acid also present in tea.

The tannic acid of tea can be estimated in various ways, but the simplest is that adopted by Lœwenthal for the estimation of tannin, by titration with permanganate of potassium. A solution of tea is made by boiling with successive quantities of distilled water until no more matter is extracted, the whole is filtered and the dilute solution made up to a definite volume. A known quantity of this liquid is then taken and mixed with a measured quantity of solution of indigo carmine, the value of which in relation to the permanganate is known. The solution is slightly acidified with sulphuric acid, and the permanganate added until the blue colour changes first to green, then to faint yellow with a slightly pink tinge. From the quantity of permanganate used, the amount corresponding to the indigo carmine is subtracted, and the remainder equals the permanganate used in oxidising the tannic, and other vegetable acids, &c., present in the solution.

A further measured quantity of the tea solution is then treated with a solution of gelatine and salt, to precipitate the tannic acid present, it is then filtered, and a measured quantity of the filtrate mixed with indigo carmine and titrated with permanganate as before. The difference between the quantity of permanganate used in the first and second instances, corresponds to the amount of tannin removed by the gelatine. The value of the permanganate in relation to oxalic acid, and the various tannic acids is previously estimated by titration with known quantities of the pure substances.

Another method employed by Dr. Hooper in certain tannin estimations in tea, and the one I had to adopt was to precipitate the tannin in the tea solution with neutral acetate of lead, commonly called "sugar of lead."

The tea solution was made in the usual manner by boiling a weighed quantity with water until all soluble matter was extracted, and the solution made up to a known volume.

A portion of this was taken and treated with a slight excess of acetate of lead, which immediately precipitated the whole of the tannic acid, and colouring matter together with most of the other organic acids present in the tea. The precipitate was collected on a tared filter, dried and weighed; it was then ignited the residue moistened with nitric acid, dried, again ignited and weighed. The difference in weight showed the amount of tannic acid and other organic acids present in the precipitate.

Dr. Hooper in a large number of analyses of teas grown at different heights, found that this lead precipitate contained on an average 50 % of oxide of lead, while in Assam teas, I found it generally contained about 46 °/₀ to 47 °/₀, varying with the concentration of the solutions and with their acidity. It is insoluble in boiling water, but almost entirely soluble in acetic acid, except a small residue containing phosphoric acid, and coloured greyish brown with traces of organic matter.

To confirm the amount of tannic acid found by the previous method a further quantity of the tea solution was treated with acetate of copper, which precipitates the tannic acid in a purer state, *i. e.*, with less admixture of other organic acids than the neutral acetate of lead. The precipitate usually contained from 38 to 38·5 °/₀ of oxide of copper, and agreed fairly closely with that obtained by acetate of lead when the conditions of precipitation were alike.

Both the lead and copper precipitates very easily suffered decomposition when washed with cold water, part of the tannin passing into solution, so that it was very difficult to obtain them free from matters carried down mechanically, and the results would therefore be slightly high. They were almost entirely free from vegetable mucilage, a large amount of which is extracted with the tannin by water, and is precipitated by a slight excess of basic acetate of lead, but contained all the dark colouring matters and pigments, present in the solution, the remaining solution being perfectly clear and colourless.

On evaporating this clear solution after removal of the excess of lead, the residue consists almost entirely of the alkaloid "theine" which can be purified by solution in chloroform or ether, &c., and recrystallization.

Another method for the estimation of tannin is that by Dieudonné, chem. zeit. 10·1067. A slight modification of which might be used as a rapid means of estimating the strength of a solution of tea. It consists in taking the density of the tannin or tea solution by means of a sensitive hydrometer at 22°C. or 71·6° Fahr. before and after treatment with dried skin powder, the tannin of gall nuts, being taken as a standard, and a table of densities of solutions varying in strength being given. The solution would be made by boiling a known quantity (10 grams) of tea with distilled water, until all soluble matter was removed, and making up the solution when cold to a certain volume, the density of which would not be higher than 1° Beaumé. A portion of the solution would be shaken frequently with powdered skin to remove the tannin, and after 24 hours filtered and pressed, the density of the filtrate being taken. The density of another portion of the original solution, at the same temperature 22°C would be taken, and the difference of reading would correspond to so much tannin, the amount being given in the table. To obtain a fine reading the stem of the hydrometer should be smeared with fat oil, and well wiped before use. A special hydrometer, showing 1° Beaumé divided into 100° is required for the estimation, together with a well made thermometer, as slight differences of temperature would considerably affect the results.

The tannin in tea is the chief causes of strength and pungency, but Dr. D. Hooper who made a large number of analyses of Indian and

Ceylon teas, found that the quantity present was not influenced by the quality of the tea, or by the altitude at which it was grown. It is probable that the " fulness " of the tea, apart from " pungency," is due to the mucilaginous constituents dissolved by the boiling water, as well as to the tannin and other soluble matter.

The amount of tannin in leaves varies according to conditions of light and shade, the former with carbonic acid being essential agents for its formation. Experiments have shown that the outer leaves of a plant exposed to direct sunlight contain more tannin than the inner leaves, also that only green leaves are capable of producing it. The young leaves of certain jâts of tea, which are of a pinkish brown colour up to the time of plucking probably contain less tannin for the above reason.

The principle function of the tannic acids, according to Möller is as glucosegenides, which act as carriers of carbohydrates from one part of the plant to another. It is supposed that the carbohydrates form with tannin readily decomposable compounds of glucosidal nature, from which upon their arrival at a part of the plant, where carbohydrates are needed, the tannic acid is separated and passes on in the circulation, the carbohydrate being deposited. Their physiological importance is however apparently very slight, as they are not removed from the leaves of deciduous trees before their fall, as is the case with starch and nitrogenous bodies, which are stored up in the stem and roots for the future use of the plant.

Tannin like starch is chiefly formed in those parts of the plant, where there is an abundance of material for its production, but it is not used as starch is for the further building up of the plant's structure. It is also supposed that its purpose is to protect the leaves producing it either from being attacked by insect enemies, or from rotting ; but from the large number of insect blights to which tea is liable, the former quality is doubtful.

Indigenous plants usually contain the largest amount partly owing to their having relatively less insoluble fibrous and cellulose matter, owing to their more rapid growth.

Gallic acid. $C_7H_6O_5$.—This constituent occurs only in limited quantity in tea, and is partly produced during the process of manufacture from the decomposition of a part of the tannic acid, but it is apparently of little or no importance as effecting the value of the tea.

It can be obtained from the tea solution after the removal of the tannic acid with glue, by evaporating to a syrup, exhausting with strong alcohol, evaporating again, and treating with ether. On the evaporation of the ether, it crystallizes out in white silky needles ; heated to 210° C it decomposes with the formation of a sublimate of pyrogallic acid ($C_6H_6O_3$).

It dissolves in 100 parts of cold, and three parts of boiling water readily in alcohol, but less readily in ether. The aqueous solution does not precipitate glue or alkaloids, but precipitate salts of oxide of iron, with a dark-blue colour, like that produced by gallotannic acid ; the gallate of iron differs from the tannate of iron by its great solubility in acetic acid, the tannate of iron being only slightly soluble. A delicate method for determining the presence of gallic acid is to treat with cyanide of potassium, a pink colour being developed which disappears and re-appears on shaking.

Its presence in tea adds slightly to the astringent taste, but owing to the tannic acid present with it, the difference would be hardly observable.

It is probable that gallic acid is formed in the leaf from the combination of phloroglucinol $C_6H_3(OH)_3$ with the nascent carbonic acid resulting from the oxidation in the cells, as represented by the formula $\overset{\text{phloroglucinol}}{C_6H_3(OH)_3} + CO_2 = \overset{\text{gallic acid}}{C_7H_6O_5}$.

Four molecules of this gallic acid may then condense, with the elimination of a molecule of water and carbonic acid to form tannin.

This condensation is not always completely carried out in plants, so that the tannin would always contain a certain amount of gallic acid.

Boheic acid. ($C_7H_8O_5 + 2\ H_2O$) ?

It is doubtful whether this so-called "Boheic Acid" is a single compound, or a mixture of two or more organic acids. The name was given from its having been discovered in China black tea (Thea Bohea) in conjunction with much tannic acid. In Assam teas it occurs in rather large quantity, and can be obtained as follows :—The aqueous extract of tea is precipitated with an excess of acetate of lead to remove the tannic acid, &c. It is then filtered, and the clear filtrate made slightly alkaline with ammonia, which immediately precipitates the boheic acid in a bright yellow flocculent form. It is then collected on a filter, washed quickly, the precipitate suspended in absolute alcohol, and decomposed with pure sulphuretted hydrogen ; the sulphide of lead filtered off, and the filtrate evaporated in a vacuum. It is a pale yellow very hygroscopic substance, and when exposed to the air gradually darkens, probably from the absorption of oxygen. Heated to 100° C (212° F.) it fuses and immediately turns dark brown. It tastes slightly bitter, dissolves easily in water and dilute alcohol, less in absolute alcohol, gives a brown colour with chloride of iron, and does not precipitate gelatine.

The lead precipitate (Boheate of lead) contained on the average 74 °/₀ oxide of lead (PbO), but this amount was not constant. About 2 °/₀ of boheic acid is usually contained in the tea solution obtained by treating with boiling water for 5 minutes, but rather more is present in the leaf. It adds to the strength and bitter taste in tea, without having the same deleterious quality of tannin, as it does not precipitate albuminoid matter.

Boheic acid apparently undergoes little change during the manufacture of the leaf, except by darkening in colour when nearly dry, practically the same amount being yielded to water at each stage when treated for 5 minutes

Green leaf	...	...	...	2·2 °/₀
Oxidised leaf	...	...	...	2·0 „
Half fired leaf	...	...	...	2·04 „

Legumin or vegetable casein.

This peculiar albuminoid substance occurs principally in the seeds of the leguminous plants, even up to 20 °/₀ or 30 °/₀, and it is to this that their nutritive value is chiefly due. In tea it also accurs up to 24 °/₀, but with the present method of drinking tea, only a small proportion is utilised, the greater part being thrown away in the leaves. It is partially soluble in cold and hot water, and almost completely in very dilute alkaline solution, from which it can be precipitated by acidifying with acetic acid, or sulphuric or hydrochloric acids.

It is difficult to obtain it pure from tea, owing to the solution of phlobaphenes, &c., by the alkaline solution, substances are precipitated with it on the addition of acid. The only satisfactory method is to estimate the nitrogen in the purified precipitate, and to calculate the amount of legumin from it by multiplying by 5·97 or 6, legumin generally containing about 16·8 °/₀ of nitrogen.

If cold water is used for the extraction, the temperature should be kept at 4° or 5° C. (40°—41°)F., but even with continued treatment only a portion is extracted, the remainder having to be removed with dilute alkaline solution (·1 %) caustic soda.

It is best obtained from tea after removal of the tannic acid, resins, &c., with alcohol and ether, by repeated treatment with the dilute alkaline solution, which is then acidified with acetic or hydrochloric acid. The legumin is collected on a filter, washed with a little cold water, redissolved in dilute soda solution, precipitated with acid and again washed.

Pure, it is a slightly yellow powder, dissolving in hot and cold water, but as obtained from tea, it is dark in colour from some contaminating pigment matter, which it is difficult to remove.

On evaporating its solution, it becomes covered with a pellicle or skin, the legumin having been converted into the insoluble modification.

To obtain more of this substance in the tea solution, the addition of a little carbonate of soda to the water is frequently made but only at the expense of all flavour in the tea, probably owing to the action of the hot alkaline solution on the essential oil. Part of the legumin in tea after the breaking up of the cells of the leaf during manufacture, becomes combined with the tannic acid also present, forming a compound insoluble in hot and cold water, and thus tending to partially neutralise the astringency due to the latter constituent; this change apparently being more complete, the more the cells are broken, and the longer the oxidation process is allowed to continue.

Accompanying the legumin in the green leaf is a small quantity of albumin and globulin, but the former is converted to the insoluble condition by the high temperature employed during manufacture, and consequently is not dissolved when the leaf is treated with hot water.

Resins.—Two or more modifications of these bodies occur in the leaf and in manufactured tea, partly produced by the oxidising influence of the atmosphere on the essential oil. When pure, they are brown amorphous tasteless and inodorous, fuse when heated, swell up and burned with a smoky flame. Insoluble in water, soluble in alcohol, and partially in ether. When boiled for some hours with dilute acid they yield sugar, which reduces an alkaline copper solution quickly, showing their glucosidal nature.

Owing to their insolubility in water, they have no effect on the strength of the tea.

They were obtained from the tea leaf, partly by treatment with anhydrous ether for some days, the ether solution evaporated at a low temperature, and the residue extracted with water to remove gallic acid and other substances soluble in that liquid. The residue insoluble in water, was then treated with alcohol which dissolved the greater portion, consisting partly of a glucosidal resin, and partly of a phlobaphene derived from the decomposition of the tannin during manipulation. Generally anhydrous ether has little solvent power for tannin, and none should have been dissolved in the above process, but its solution was partially due to the small quantity of moisture present in the leaf. The residue after exhausting with alcohol, was treated with an alcoholic potash solution, which completely dissolved it, and the substance (an acid resin) was recovered from this solution by acidifying with acetic acid.

A further quantity of resinous bodies was extracted from the residue insoluble in ether, by means of absolute alcohol. The brown extract after removal of the alcohol, was treated with water to remove tannin, &c., and the insoluble residue purified by resolution in alcohol and partial decolorisation with animal charcoal. All the colouring matter could not, however, be removed by this means.

The still dark coloured residue had properties similar to the resins, but probably contained some product of the decomposition of the tannin, which had taken place during the process of analysis. It is evident from the figures obtained of the different constituents soluble in the various solvents employed for the analysis, that chemical change is continually going on in the leaf while under treatment, either by the constituents undergoing decomposition or oxidation in themselves, or by their forming new compounds of different solubility with others also present. To thoroughly investigate all the complicated chemical changes a long period of careful study would be required, which however, would probably prove of little practical benefit to the planter, as it is only the changes uudergone during the few hours of manufacture, which it is necessary he should be able to control and regulate.

Wax.—This occurs in small quantities in tea leaf, it being said to form a protective covering to the leaf during growth. In the process of manufacture this covering is broken, and the leaf becomes more exposed to the action of the surrounding atmosphere. It is dissolved together with the essential oil, when the leaf is treated with petroleum ether or ether, but is insoluble in water. Its function is apparently to prevent too rapid evaporation from the surface of the leaf during dry hot weather, and so prevent the leaf from fading, and the slow withering of the plucked leaf during cold damp weather is no doubt augmented by its presence.

It was probably for this reason that the Chinese toss and pat the leaves to hasten the withering process by destroying the coating of wax, and so allowing more rapid evaporation of the moisture.

It has no effect on the strength or flavour of tea being insoluble in water, nor does it apparently effect the appearance of the rolled and dried leaf to any extent.

Mucilage.—Pectin, pectoses, &c., a comparatively large quantity of these substances occur in tea, and assist in giving thickness to the liquor. They are not however, completely soluble in water, but are dissolved almost completely by treatment with dilute alkaline solution from which they can be precipitated by acidifying slightly with acetic acid, and mixing with three volumes of 90% alcohol. The precipitate thus obtained contains large quantities of lime salts, chiefly the phosphate of lime, which can be removed by treatment with alcohol containing a little hydrochloric acid. The mucilage dissolved in cold water and precipitated by alcohol was easily converted into glucose when boiled with a dilute acid.

The precipitate obtained from the dilute alkaline solution consisted of pectin and albuminoid substances (legumin), the latter being estimated in the dried and weighed precipitate, by determining the amount of nitrogen contained, and calculating from this.

The presence of this mucilage in the water solution of tea renders its filtration, a slow and tedious process, unless maintained at boiling water temperature, since on cooling it undergoes partial gelatinisation and so chokes the pores of the filter. This is still more observed in an alkaline solution of tea which contains a much larger quantity of pectin and mucilaginous substances.

The creaming of tea is apparently partly due to this property, as the opaque appearance can be removed, and the solution rendered clear and bright by heating it to a temperature of 46° C. or 114°·8 F.

Chemistry of Tea.

In investigating the chemical changes undergone by the tea leaf during manufacture, complete proximate analyses were made of the fresh green leaf and of the manufactured tea, and certain of the constituents, which were found to undergo chemical changes affecting the strength and flavour of the tea, were estimated by separate analyses at every stage of the manufacture. These constituents were also isolated in a pure state, and their chemical properties ascertained when subjected to different conditions of temperature and moisture.

The method of analyses adopted was that recommended by Dragendorff, and consists principally in the separation of most of the constituents by means of various solvents. It was found, however, that certain constituents were only partially dissolved by some of the solvents, which considerably increased the difficulty of the analyses, and at the same time showed that they must exist in more than one modification.

The first consideration was to obtain the green leaf in a suitable condition for analyses, without causing it to undergo chemical change. This was done as far as possible by drying the leaf over strong sulphuric acid at as cool a temperature as possible, and when dry the leaf was very finely powdered in a mortar and preserved in an air-tight bottle for analysis. This powdered leaf remained in an unchanged condition for some months, after which time it absorbed a small quantity of moisture and developed an aromatic mint-like odour, and ultimately became covered with a fine greyish mould.

The manufactured tea was prepared from a sample taken immediately after the drying process and before sorting, by powdering in a mortar and preserving in the same manner as the green leaf. This also remained unchanged for some months, but ultimately became mouldy from the access of moist air when the bottle was opened, but no aroma as in the other case was developed.

Although the powdered leaf in both cases appeared and felt perfectly dry, it still contained a certain percentage of moisture, which was estimated by drying a small portion at the temperature of boiling water, until it ceased to lose weight. With this moisture a portion of the essential oil was also probably driven off, but owing to the very small quantity at any time present in the leaf, and the difficulty of estimating this constituent, the quantity so lost could not be determined.

The small portion of leaf used for the estimation of moisture was then burned to ascertain the amount of mineral matter or ash.

This ash could only be freed from carbon by mixing with it some nitrate of ammonium, and re-igniting. It was fusible to a certain extent and developed a bright green colour, owing to the presence of manganese. A complete analyses of the ash will be found on another page.

The first solvent used was petroleum spirit, which if pure should extract only the etherial and fatty oils, wax, a little resin, and traces of the alkaloid "theine." Unfortunately this solvent was not pure, and owing to its high boiling point, and to its leaving a strongly smelling residue at 130C. it could not be employed for the delicate estimation of the essential oil, which had to be estimated by distillation with steam, and separation from the distillate by means of ether.

Twenty grams of the dried leaf and tea were taken in each case for analysis, and the whole of the operations throughout were conducted in as nearly the same manner as possible to insure comparable results.

The twenty grams were treated with 200 cubic centimetres (c. c.) of petroleum ether for eight days in a closely stoppered flask, with frequent agitation. The solution became a bright green colour from the presence of part of the chlorophyll of the fresh leaf. Ten c. c. were then drawn off and evaporated to dryness in an open vessel, and finally heated to 100° C until constant. The residue contained more resinous matter than would have been extracted had the petroleum ether been pure and boiling at a temperature below 45°c.

The residue was not completely soluble in absolute alcohol. It was treated with water acidulated with sulphuric acid to remove any theine, and shaken in a separator with ether to dissolve any cholesterin if present.

The acid solution was separated from the ether, made alkaline with carbonate of soda, and again agitated with ether and chloroform to remove all the theine.

The latter ether solution was then evaporated and the theine deposited in fine silky needles, which were dried and weighed.

The other ether solution was also evaporated to dryness, and the residue heated for some hours with alcoholic potash, it was then evaporated to dryness, treated with water and the solution again shaken with ether to extract the cholesterin. The ether solution was separated, evaporated to dryness, and the minute residue tested for cholesterin by treatment with strong sulphuric acid and chloroform, which should yield a red colour, but with only negative results. As however cholesterin only occurs in plants in very minute quantities, a further treatment of a large quantity of leaf might reveal its presence, though it probably has little or no effect on the value of the tea.

The distillate, obtained by distilling fresh green leaf with water, had a neutral re-action, showing the absence of any volatile fatty acids, and a peculiar vegetable odour. On shaking in successive portions with ether, a small quantity of essential oil was obtained, having a powerful etherial smell, which disappeared after 24 hours' exposure to the atmosphere, owing to the spontaneous evaporation of the oil. Under the microscope this essential oil appeared as colourless irregular drops, which were soluble in cold alcohol.

The facility with which the essential oil can be obtained from tea, by being carried away by steam at 212° F. under the ordinary atmospheric pressure is an important fact, which must be considered in the manufacture. Usually the oxidised, or as it is commonly known "fermented" leaf is exposed suddenly to a powerful current of air at a temperature ranging from 250° to 280° F. which carries off the moisture as steam very rapidly. At first, however, the rapid evaporation keeps the leaf at a temperature considerably below that of the heated air, but as the leaf gets drier, the temperature rises, and the remaining moisture in the leaf attains the temperature of boiling water, and the generated steam is carried away, removing with it a considerable portion of the essential oil. This was proved by the analyses of the leaf made under strictly comparable conditions at the end of each stage of the manufacture. The figures are calculated on the dry matter in the leaf.

Green leaf (dried over sulphuric acid) contained	·015	%
Fermented or oxidised leaf	·027	,,
Partly dried leaf (50%)	·035	,,
Completely dried leaf	·025	,,

Extraction with Ether.

The residue of the leaf after extraction with petroleum ether was exposed to the atmosphere and then in vacuo to remove as far as possible any traces of that solvent. It was then treated with pure ether in the same proportion as before for several days, to remove any resins of which tea contains a considerable quantity. Before use the ether was stood over Chloride of Calcium for some days to remove any moisture, but notwithstanding this precaution, it dissolved out a portion of the tannic acid, which is usually insoluble in pure anhydrous ether.

A small quantity of the clear solution, which in the case of the leaf was bright green, and of the tea, brown, was evaporated to dryness to estimate the total quantity dissolved.

The remaining solution was distilled under reduced pressure to recover the ether, and prevent change as much as possible. The residue was triturated with washed sand and treated with distilled water to remove such substances as gallic acid, glucosides and alkaloids, which were then estimated separately. The residue insoluble in water was then dried and treated with alcohol to dissolve the resins, and the residue insoluble in alcohol was treated with a solution of Alcoholic Potash in which it was completely soluble. By this means it was found that the resins soluble in ether had not undergone any appreciable change during the manufacture. Those resins which were soluble in alcohol were partly of a glucosidal nature, being very easily converted into sugar, which rapidly reduced an alkaline copper solution. It is probable that the flavour of tea is partially due to these resins, which are formed during the growth of the leaf, and not developed to any extent by any process in the manufacture.

The portion of tannin dissolved by the ether had re-actions similar to gallo-tannic acid, and yielded a deep blue precipitate with a stale solution of sulphate of iron. Rather more of this tannin was dissolved from the green leaf, than from the tea, owing probably to more of the tannic acid in the latter case having been rendered insoluble, either through combination with a portion of the albuminoid matter in the leaf, or from having undergone partial conversion into gallic acid and sugar, or into insoluble phlobaphenes.

The watery solution of the ether extract containing the gallic acid, glucosides and alkaloids was first slightly acidified with sulphuric acid, and shaken with petroleum ether to remove any salicylic acid that might be present, but none was found. The petroleum ether was then separated, and the water solution shaken with benzene which removed traces of theine, and deposited it in crystals on evaporation.

After treatment with benzene and separation, the water solution was shaken with chloroform, which removed a larger proportion of the alkaloid.

Both petroleum ether and benzene have very little solvent power for theine, a large proportion of the alkaloid remaining undissolved even after prolonged treatment with the solvents. Chloroform however, has a much greater solvent action on theine, but repeated treatment is necessary to ensure the removal of all traces of the alkaloid.

After shaking with chloroform, the water solution was treated while still acid with petroleum ether, to remove traces of dissolved chloroform, and after separation was rendered slightly alkaline with a dilute solution of ammonia, and again shaken with petroleum ether, benzene and chloroform in succession to try and discover the presence of other alkaloids. Both the petroleum, ether and chloroform dissolved minute traces of some compounds, but the quantity was not sufficient for identification by means of micro-chemical tests or ultimate analysis. Messrs. Paul and Cownley had previously discovered an alkaloid possibly the same. They treated 200 grains of tea in the usual manner for theine, after the whole of which had been extracted from the acid solution by chloroform, the solution was made alkaline with caustic potash and again shaken several times with chloroform. On evaporation of the chloroform solution a very small quantity of a yellow and apparently amorphous alkaloid was obtained, that dissolved readily in acid and was reprecipitated by caustic potash. It was almost insoluble in hot water, readily soluble in ether, the latter proving it to be neither theine nor theobromine. A. Kossel has also described the discovery of a new base (alkoloid) in tea, in Berichte der deutschen Chemischen Gesellschaft 1888. No. 2, page 2164. An abstract of which appeared in the Pharmaceutical Journal, Vol. XIX [3] P. 41., and is given here :—

" The author has ascertained the presence of a new base that is " associated with theine in minute proportion in tea extract. The " syrupy extract was treated in the following manner :—mixed with " water, sulphuric acid added to separate smeary products, and the result- " ing liquid super-saturated with ammonia, ammoniacal solution of silver " nitrate was then added and the precipitate collected on a filter.

" The precipitate was digested with warm nitric acid, the mixture " filtered to separate deposited silver salts, and the filtrate made alkaline " with ammonia. In 24 hours a brown amorphous precipitate was de- " posited, which contained the new base in the state of a silver compound, " and by evaporating the clear filtered liquid, a further quantity of this " silver compound was obtained. After separating the silver from it by " sulphuretted hydrogen and filtering, a small quantity of xanthine was " deposited from the clear filtrate, and upon concentrating the liquid, the " new base partly crystallized out. The mother liquor was then mixed " with mercuric nitrate solution, the precipitate collected, and the filtrate " made alkaline with sodium carbonate solution. A white precipitate was

" thus obtained in both cases, which consisted almost entirely of a mercury
" compound of the base.

" The analysis of the new base (called Theophylline) showed.—

Carbon	...	...	...	46·63
Hydrogen	...	...	...	4·77
Nitrogen	...	...	...	31·66

Calculated for $C_7H_8N_4O_2$ Theobromine.

Carbon	...	...	...	46·67
Hydrogen	...	...	...	4·44
Nitrogen	...	...	...	31·11

" The crystals contain one molecule of water which is given off by " heating to 110°C. The composition is therefore the same as theobro- " mine and paraxanthine obtained by Thudicum and Salomon from urine, " but the characters of the base are different from those of either " substance.

Theophylline	Theobromine
" very soluble in Ammonia water.	sparingly soluble in Ammonia water.
" Melting point. 264°C.	Sublimes without melting @ 290°C.

Paraxanthine @ 280°.

" Theophylline forms definitely crystallizable salts with hydrochloric " and nitric acids, platinum tetrachloride, and gold terchloride, and a " crystallizable sparingly double salt with mercuric chloride. In a pure " state the base is not precipitated from a dilute solution of mercuric " nitrate.

" Theophylline resembles theobromine in forming a silver compound, " which separates in an amorphous state on adding silver nitrate to a " watery solution of the base. This compound is soluble in warm ammo- " nia, and on cooling the solution it crystallizes out. Dried at 130°C., this " contains 37·18 % of silver corresponding to the formula $C_7H_7N\ O_2A_g$. " It dissolves readily in nitric acid.

" When theophylline is mixed with chlorine water and evaporated " a scarlet coloured residue is left, which becomes violet on addition of " ammonia as is the case with theobromine.

" The silver compound heated with a calculated portion of methyl " iodide and some methyl alcohol in a closed tube for 24 hours at 100°C, "gave a crystallizable product, the composition and characters agreeing "perfectly with those of caffeine; the melting point of the substance "thus obtained was 229°C., and accordingly from this experiment it may "be inferred that theophylline is dimethylxanthine. The position of the "methyl groups have yet to be determined by an oxidation experiment.

Extraction with Absolute Alcohol.

The residue after extraction with ether was dried at the ordinary temperature, and treated with absolute alcohol to remove the remaining tannic acid, resins, alkaloids, glucoses, &c. After treating for some days a known quantity of the clear solution was evaporated to dryness and the residue weighed. In the case of the tea this extract was remarkably small, showing either that the tannic acid had undergone considerable change, or that it was very little soluble in absolute alcohol. To prove this, the tannic acid from another portion of the original sample was extracted with water, precipitated from its solution by neutral acetate of lead, and the washed precipitate decomposed with sulphuretted hydrogen; the sulphide of lead was then filtered off and the solution containing the tannic acid evaporated to dryness at a low temperature, and finally in a partial vacuum over sulphuric acid.

The residue, which consisted almost entirely of tannic acid, was brown in colour, and had a pungent, bitter astringent taste. It was insoluble in ether and petroleum ether, *slightly soluble* in absolute alcohol, easily soluble in dilute alcohol, and in cold water; it gave a blue black colour and precipitate with ferric chloride, but not with pure sulphate of iron, and precipitated gelatine at once. The reason that so little of the tannic acid was extracted from the tea by absolute alcohol, was therefore chiefly due to its being only partially soluble in that liquid, and not entirely to its having undergone change during the process of manufacture.

The remaining alcoholic solution was distilled under reduced pressure and finally evaporated to dryness over sulphuric acid.

The dried residue was then treated with a known volume of water, and an aliquot part of the solution evaporated to dryness and the residue weighed.

A portion of the water extract was then treated with a solution of neutral acetate of lead, to precipitate the tannic acid present, it was then filtered and the filtrate made alkaline with ammonia, which precipitated the so-called "boheic acid." Another ordtion was precipitated with acetate of lead as before, filtered, the filtrate treated with a slight excess of sulphuric acid to precipitate the lead as sulphate, and again filtered. The filtrate was then made up to a known volume, a portion tested directly for glucose with Fehling's copper solution, and another portion after boiling for half an hour with an upright condenser, any sugar found in the latter case being calculated as saccharose or cane sugar.

The water solution after removal of the tannin by acetate of lead had a sweet taste, and a strong odour of roast apples. It reduced the alkaline copper solution immediately, indicating the presence of a small quantity of sugar in the green leaf, which however, was probably present only as an intermediate product in the sap of the young leaf.

It also contained some of the theine, which was removed by shaking repeatedly with chloroform, and distilling off the latter.

The residue of the alcoholic extract insoluble in water consisted partly of a glucosidal resin and partly of phlobaphene, resulting from the oxidation of the tannin : it was dark brown in colour and tasteless, and when boiled for a short time with a dilute acid, yielded sugar readily.

More of this resin was obtained from the green leaf than from the tea, indicating that some chemical change had taken place in the latter case, but as the substance is insoluble in water, and tasteless, the change is probably of little importance as affecting the quality or strength of the tea.

A certain amount of gallic acid was obtained from the tea in the alcohol solution, which had resulted from the conversion of part of the tannic acid into gallic acid and sugar.

This was estimated in a portion of the water solution of the alcoholic residue after removal of the tannin with gelatine by shaking with acetic ether, separating and evaporating under a partial vacuum : the gallic acid crystallized out and was purified by recrystallization.

Extraction with cold water.

The residue left after extraction with absolute alcohol was dried at a temperature of 40° C. until the last traces of alcohol had been dissipated, and then treated with cold distilled water for 24 hours. The solution was then filtered, and the residue again macerated and washed until the washings left only a trace of residue.

The total filtrate was made up to a known volume, and an aliquot portion evaporated to dryness to estimate the total matter dissolved ; the residue was then burned and re-weighed. Another portion was mixed with two volumes of absolute alcohol, and stood in a cool place for 24 hours to precipitate the mucilaginous substances soluble in water. The precipitate was collected on a weighed filter, washed with 66°/₀ alcohol dried and weighed ; it was then burned and re-weighed, the amount of ash, which was considerable, being deducted. The high percentage of ash showed the probable presence with the mucilage of some organic acid, most of the ash soluble in water being contained in this precipitate.

The mucilage which amounted to a little over 1°/₀ was boiled for some time with dilute acid, when it acquired the property of reducing an alkaline copper solution, having been converted into glucose.

The water solution had little of the taste of tea, but when a portion was evaporated to dryness, the residue had a strong odour of sugar. It was dark brown in colour and contained a certain amount of tannic acid precipitable by gelatine, which had not been removed by the alcohol. This constant occurrence of tannin in the different solution made the estimation of the other constituents more difficult as it was impossible to remove it from solution without introducing other foreign matter as gelatine or hide ; it also tends to show that more than one kind of tannic acid is present in the tea. After separation of the mucilage as above described, the filtrate was concentrated and again mixed with 4 volumes of absolute alcohol, which precipitated the dextrin and gummy matters, more easily converted to sugar than the mucilage.

The filtered solution, when all the alcohol had been dissipated by evaporation was treated with neutral acetate of lead to precipitate the organic acids not removed by alcohol. The precipitate, which almost entirely consisted of the tannate of lead was collected on a filter, washed with water, dried and weighed. It was then incinerated and weighed again the difference in weight representing the tannin. Qualitative tests were made for other organic acids, but with negative results.

Glucose was also looked for in a portion of the filtrate from the dextrin, after the removal of the alcohol, but was not present.

A small portion of the legumin in the leaf occurred in the water solution, and was removed by precipitation with hydrochloric acid.

Another estimation of albuminoids was however, made in a water solution of the fresh substance, without previous extraction with ether, alcohol, &c., a weighed portion of the original powdered tea, was macerated with water at as low a temperature as possible, but this treatment only removed a small portion of the legumin, which is more easily removed by a dilute alkaline solution. A kuown quantity of the aqueous solution in the cold was acidified with hydrochloric acid to precipitate the legumin, care being taken to exclude carbonic acid. The precipitate was collected on a tared filter, washed with acidified water and 40% alcohol, dried and weighed. It was then iucinerated and weighed again to estimate the ash. The total nitrogen in the tea was estimated before and after extraction with water, also after the final extraction with dilute alkaline solution. From the difference the nitrogen found as legumin above was subtracted, the remainder representing the nitrogen dissolved in water as ammoniacal salts, amides, alkaloids and nitrates.

Extraction with dilute caustic soda ·1%.

The residue insoluble in water was suspended while still moist in ·1 per cent. solution of caustic soda for 24 hours, the solution was then filtered through fine cloth, as paper was immediately clogged, and the residue again treated with fresh alkaline solution until all soluble matter had been removed. The filtrate was made up to a known volume, a portion acidified with acetic acid and mixed with 3 volumes of 90% alcohol, and allowed to stand for 24 hours in a cool place. The precipitate consisting of mucilaginous substances and albuminoids was collected on a filter, washed with 75% alcohol, dried and weighed; the ash being deducted in the usual way. Another precipitate obtained in the same way was after washing, drying and weighing used for the estimation of nitrogen contained in it, the amount of albuminoids calculated from this being substracted from the weight of the precipitate, gave the amount of mucilaginous substances.

The constituents soluble in caustic soda, however, have little or no effect on the commercial value of the tea.

The following table shows the quantities of the constituents of fresh leaf and prepared tea soluble in the different solvents employed in the preceding analysis :—

Solvent.	Total Extract. Leaf.	Tea.	Constituents.	Percentage. Leaf.	Tea.
Petroleum Ether	3·755°/o	1·74°/o	Essential Oil	·015 °/o	·025 °/o
			Fat and resins	3·740 „	1·715 „
Ether ...	8·34 „	7·76 „	Resins ...	1·36 „	1·40 „
			Thein ...	·37 „	·28 „
			Tannin ...	6·61 „	6·07 „
Alcohol ...	6·90 „	3·94 „	Glucose ...	·25 „	·00 „
			Theine ...	1·52 „	·92 „
			Gallic Acid ...	·00 „	·87 „
			Tannin ...	5·12 „	2·14 „
Water ...	9·90 „	13·60 „	Gun ...	1·12 „	1 28 „
			Dextrin ...	1·76 „	2·70 „
			Tannin ...	2·76 „	3·60 „
			Legumin (albds.)	1·42 „	3·02 „
			Ash ...	2·84 „	2·40 „
Caustic Soda (1°/o Solution) ...	28·00 „	33·50 „	Pectin ...	12·60 „	8·30 „
			Legumin ...	15·40 „	18 00 „
			Phlobaphene ...	·00 „	7·20 „
Insoluble residue	43·095 „	39·46 „			
	100·	100·			

The whole of the Theine is not extracted by the above method of analysis, but could be obtained from the residue consisting of cellulose, fibre, colouring matters, &c., by treatment with dilute solution of Sulphuric Acid. It is best obtained, however, by the method given in a preceding paragraph. The total quantity present in the leaf and tea was 4·25 °/o showing that no loss of this constituent takes place during the various processes of manufacture.

The total Nitrogen in the leaf was 4·90 °/o of which 1·19 °/o was contained in the Theine, and 3·71 °/o in the Legumin and small quantities of Amide bodies. A certain proportion of the Legumin remains in the insoluble residue after extraction with the above solvents, amounting to about 5 °/o in the leaf and 2 °/o in the tea. The rapidity with which the Tannin undergoes change in its solvent and other properties, by oxidation through the absorption of oxygen from the air, renders its estimation in the above manner very difficult; hence several determinations of this constituent were made by more direct and rapid methods, which confirm the theory that a large proportion of the Tannin is altered, and its astringency destroyed during the oxidation and firing processes, without reducing the total amount of soluble matter in the leaf. The quantity of soluble matter varies considerably throughout the season, depending largely on the kind of weather previous to, and at the time of, plucking.

It varies in fresh leaf from about 40 % to 44·67 %, and in prepared tea from 44·9 % to 46·3 %, calculated on the dry leaf. The average total extract in Indian teas, however, is said to run from 37·8 % to 40·35 %, Ceylon teas from 38·4 % to 43·02 %, and China (Common Congou), about 26·20 %. The respective percentages of Theine are also stated to be :—

Ceylon ...	... ...	1·64 to 2·18 %
Indian ...	... ...	1·88 „ 3·24 „
China and Japan	... ...	1·08 „ 3·46 „

(Some useful tables and papers relating to the analysis of tea, and showing the composition of Ceylon, Indian, Japan and China teas will be found in the appendix.)

CULTIVATION.

CHAPTER V.

Cultivation of tea soils at the present time is confined almost entirely to hand-weeding, forking, or hoeing, chiefly the latter, and the amount and kind of such cultivation is regulated more by the amount of labour available on the garden, than by the requirements of the different classes of soil. It is a well-known fact in agricultural practice, that heavy and light soils must have very different treatment, if successful results are to be obtained, and the same thing holds good in respect of tea soils, though as a rule it seems to be lost sight of. It must be remembered that it is as easy to over cultivate some soils, as to undercultivate others, resulting in both cases in detriment to the bushes.

The main feature in the treatment of light sandy soils is to render them as far as possible more compact, retentive and absorbent; while in the case of heavy soils, the object is to lighten and aerate them, and reduce their retentive qualities for water to within certain limits.

LIGHT (*sandy*) SOILS.—Such soils do not require so many hoeings during the year as heavy soils, as they are more porous and exposed to the action of the atmosphere. They are benefited greatly by the burial of jungle, which, if the intervals between the hoeings are prolonged, will be no inconsiderable amount. These soils are generally rather poor in organic matter, due chiefly to their porosity having greatly hastened its oxidation by the oxygen of the atmosphere; and as tea does not yield a large outturn on soils which have little organic matter and nitrogen, it is necessary to retard this change to some extent, and at the same time, by the hoeing in of fresh organic matter, either increase, or at least retain a fair percentage in the soil.

Many have an objection to seeing jungle growing on any class of soil among the tea, as it is supposed to take up the plant food required by the latter, and so check its rate of flushing. If the jungle was allowed to grow too long, it would no doubt be detrimental to the bushes, not only by removing from the soil certain constituents that the tea required, but also by preventing the free access of air. It is not necessary, however, to allow the jungle to grow to that extent, nor would it do so if hoed and *covered* in thoroughly four or five times during the season. If this is well done, it would be some days before any new growth appeared, and as the hoeing would be repeated in about six weeks from the date of the previous one, the new jungle would not have had much opportunity of sending its roots to a depth that would affect the roots of the tea. It is also to be noticed, that the jungle, besides as a rule being shallow-rooted, is of a completely different order to the tea itself, and would remove temporarily from the soil those constituents that were not so urgently required by the tea, as in the ordinary system of rotation of crops. It is a curious fact that tea garden jungle in any district rarely contains plants of the natural order "Leguminosæ" as the clover or gram, perhaps partially due to all tea soils containing such a small proportion of lime. Trees of this order, as the "sau" have been planted among tea in some gardens, as it was originally noticed that its presence appeared to have a beneficial effect on the bushes, but it is now being generally removed as its shade has been found detrimental to outturn to a great extent, and counterbalances any other benefit derived from its use.

A great advantage would I think be gained if the jungle growth could be gradually and economically changed to the above natural order, as its powers of enriching soils with nitrogen, which it derives indirectly from the atmosphere, would make it the cheapest means of supplying that useful and necessary constituent to the tea.

By gradually increasing the amount of organic matter in sandy soils, they are rendered more hygroscopic and retentive of moisture, so that the soil would not become so dry during a long interval of dry weather, as sometimes occurs in the rainy season; also during the cold weather the plants would not be so liable to suffer from drought, or to die out when heavily pruned to the ground.

To obtain the full benefit of the jungle that is hoed in during the season, it is necessary that it should be completely buried at each hoeing, otherwise if allowed to become sun-dried it will remain in the soil for a long period undergoing but slight change, and instead of consolidating the sandy particles, will only tend to lighten them. When buried green and moist, partial decomposition will set in immediately, and before the next hoeing it will have assumed a rich mould-like appearance, and can then be easily disseminated through the soil.

In many districts where Cacharee labour is chiefly employed, it would be found very difficult to get such thorough work done, especially if the jungle was allowed to grow to any extent, but there is no doubt that four or five such hoeings would give better results than seven or eight of the ordinary Cacharee method, when within two or three days the garden looks as if it had not been touched for weeks, owing to the careless way in which their work is usually performed.

There is no doubt that that Bengalees do far better work in hoeing than the former, and if there is a sufficient labour force on the garden to give a few good hoeings during the year, instead of a larger number of poor ones, it would be better to dispense with the Cacharee labour altogether, or until such time that they became less independent from there being a lower demand for their work. In a few instances they have been made to do good work at the usual rate of pay, but this appeared to be the case only at those gardens where they had every convenience in the way of living, and so did not like to leave the spot.

The only method of hoeing that would bury the jungle thoroughly would be to give what is generally called a double hoeing, only on a reduced scale ; this is done by making a slight trench, at a depth that would not expose or touch the roots of the tea bush, lightly scraping the jungle into it, and then covering it with the next hoe of earth, which would leave another trench ready for more jungle.

At the end of the flushing season, and after the pruning, the soil should be hoed deeply and left as rough as possible for the cold weather.

Unless the prunings are very light it is unadvisable to bury them in an open, sandy soil, as large, coarse prunings by their slow decomposition, would only make the soil more porous than ever. The final hoeing should not be delayed too long into the cold weather, but should be done while the soil is still rather moist, which will cause an immediate decomposition of the buried jungle, and assist in preserving moisture in the soil.

HEAVY (*clayey*) SOILS.—The object here is to make the soil more open in texture, and pervious to air and rain. To accomplish this it would be necessary in the first instance to thoroughly drain the soil, which subject will be treated of hereafter.

More hoeings, but of the same description as those described before, will be required for this class of soils throughout the rainy season, owing to their tendency to become consolidated on the surface, when exposed to heavy rainfall or to the treading of the coolies in plucking. These soils should, if possible, never be hoed during heavy rain, or when completely saturated with moisture, as hoeing at such times is certain to make them more consolidated and compact than ever, rendering future hoeings more laborious and expensive. If the hoeing is done when the surface soil has become a little dry, it will be found that the soil will not become as adhesive as before, and if this method is continually practised, it will rapidly become more open and friable. Clayey soils that have been cultivated badly during the rains, are always hard and compact during the cold, dry weather, so that when broken up by the deep hoeing, much damage is often caused by the breaking of the roots of the tea plants, which have become locked in the hard mass of soil. The burial of organic matter is almost as important on heavy as on light soils, as in both cases it adds to the fertility of the soils, besides having certain mechanical effects. In the case of heavy soil it is not so necessary to bury it in a wet and green condition, as it is required to keep the texture of the soil open and permeable to air, but even in this case it is preferable to bury it, and so insure its being killed. Larger prunings could also be buried in clay soils than in sandy ones, and the deep hoeing for the cold weather should be done as far as possible after pruning, so that the soil, when left rough, may not be broken down and levelled by the pruners walking over it. A coolie cannot, of course, hoe so much of heavy as of a light soil in a day, but with careful treatment, cultivation of the former will yearly become easier, owing to its greater friability, and larger tasks can be given.

Opinions, are very diverse as to the possibility of cultivating successfully with forks (digging) in the place of hoes, but some excellent work has been done with the former, when once the coolies have become accustomed to their use. For heavy soils, they are I think, preferable to hoes, as they penetrate the soil more easily, and leave it in a more broken condition than the latter. The chief objection raised against them is that they bend and twist the roots, and so cause greater damage than if the roots were cut completely through with the hoe. This, however, is not likely to be the case in soil that has been kept open and friable by proper cultivation, and where the fork is used correctly, *i. e.*, by digging round the bush, commencing close to the stem and gradually extending the circle of cultivation. The branches of the bushes are also less liable to be damaged by their use, as serious injury is often caused by the heavy downward stroke of the hoe. For hill gardens they have a further advantage in enabling the soil to be turned upwards round the bushes, and so remedying to a certain extent the effect of wash.

On all classes of soils a certain amount of handweeding must be done round and underneath the bushes, to clear away any grasses, ferns, &c., which may have grown up among the branches, as it is necessary to allow as free an access of air to the interior of the bush as possible. On hilly gardens handweeding should be done throughout the rainy season, in order to prevent wash of the soil by rain, as the latter is bound to occur where the soil is being continually loosened by cultivation, resulting in rapid deterioration of the garden, or the expenditure of large sums to replace the soil so removed.

It is as a general rule unnecessary to touch the soil again until the early spring, after it has been roughly turned up by the deep hoe, but if it is very dirty with a class of weed such as the ooloo grass, it would be better to eradicate it as much as possible by hoeing, forking, or handweeding during the hot dry season, when it would be most easily destroyed. The rapid growth of this grass during the rains makes hoeing doubly hard where it is prevalent, and considerably enhances the cost of cultivation, besides always having an unsightly appearance, and being of itself of little value as a green manure when hoed in.

The growth of other classes of weeds of a different natural order to the Graminaceæ or grasses, is an advantage during the cold weather, as they are gradually accumulating from the atmosphere, at a time when the Tea plant is practically dormant, large quantities of carbonic acid and some nitrogen, which, when the weeds are buried and decomposed, are again liberated for the use of the Tea.

One reason why the annual deep hoeing should be given *early* in the cold weather is, that any bushes injured by having their roots cut or damaged in any way, have a longer period to recover, before the growing season recommences, and the plants have to send out new shoots.

It is probable that root growth continues to a certain extent during the cold dry season, although there is no evidence above ground to show it, and during this growth they are accumulating stores of mineral and other plant food in their cells, which is utilised in sending out new branches and shoots in the spring. If, therefore, some of the main roots are cut off by the hoe during a late deep hoeing, as is often the case, the resources of the bush are diminished, and it is unable to flush readily until new roots have penetrated into the surrounding soil.

DRAINAGE.—In selecting a site for a new clearance, one of the most important points to be observed besides the character of soil chemically and mechanically, is the possibility of removing all excess of water by natural or artificial means. Large areas of Forest and Grass land have been cleared without taking this into consideration, and it has been found sooner or later, that the position is totally unsuited for the growth of tea, and either has to be abandoned or large sums expended in cutting huge water-courses to the nearest river, or point where an outlet for the water can be obtained. Several gardens are almost directly on the level with rice lands, the water from which, when flooded, backs up any drains that may be cut, and prevents the removal of water from the roots of the bushes for days and weeks together. Under such circumstances the Tea plant will never flourish, and will prove a continuous disappointment to the owners, and those who are managing such an estate.

That soils of an open, porous character and free from stagnant water are the most suitable for Tea has been known ever since its introduction and discovery in Assam, and later experience has shown, that drainage properly performed has in almost every instance proved of the greatest benefit to the plant. Its effects are not merely the removal of water, but are also equivalent to a permanent cultivation to the depth of the drains employed ; for by its means the soil is rendered more open, porous, and friable, and air is admitted through the numerous channels formed, deep into the subsoil where it can act chemically on the organic and inorganic constituents, and assist in liberating them from their insoluble combinations for the immediate use of the plant.

Well-drained soil is also far warmer than a badly-drained one, for in the former the water passes away from beneath, and draws the warm air deeply into the soil, thereby increasing its temperature; while in the latter, the water is removed by evaporation from the surface, causing a considerable lowering of temperature, which the Sun's rays cannot prevent, as the greater the heat from the latter, the more rapid the evaporation, and the greater the coolness produced. Cold water also being heavier than warm, has a tendency to sink and displace the warmer water below, which is thus brought to the surface, where it undergoes a similar cooling action. It will thus be seen that a drained soil will get warm much sooner in the season than an undrained one, and therefore the bushes growing on the former will also commence to flush earlier, what is known as "bottom heat" being essential for free and rapid growth.

It is sometimes thought, that drainage will render a soil and the plants on it more liable to suffer from drought during a long period of dry weather, but this is not the case, as the soil is more porous to a greater depth, and water can rise more easily from the subsoil owing to its improved capillarity.

In the case of undrained clayey soils, when once the water has evaporated from the surface, the soil contracts into hard masses, and the deep subsoil water has little power of rising to the surface, or even sufficiently far to maintain the plants in an uninjured condition. This contraction of badly-drained soil also frequently causes serious damage to the roots of the bushes, by hardening round them, and fracturing the tender rootlets.

Stagnant water in a soil also largely prevents the proper formation of nitrates, and causes a certain amount of reduction in those already formed, and consequent loss of nitrogen to the plant. It also assists in the production of certain poisonous compounds, which if assimilated by the plants, would either kill them, or effectually prevent any healthy growth.

Of course it is not all soils that require drainage, and much harm might be done by adopting it in every case; easily friable open soils with a free subsoil, from which the water can easily percolate to a ower level, would certainly not be benefited by it, but the reverse.

The depth to which drainage should be carried out depends chiefly on the character of the soil, and the width apart of the drains, but within certain limits the deeper the drains are dug the better, as the larger the feeding area available to the bushes.

When a bush is planted on an undrained soil, the roots descend until they reach the surface or upper level of the stagnant water, which would entirely prevent their penetrating into the soil beneath, consequently the feeding area of the bush is restricted to the soil above that level; but if the water level is lowered by drainage, the roots will descend also until they are again stopped by the stagnant water, therefore the lower the drains are made the greater the feeding area of the bushes. As the roots will now be able to obtain their food from a lower depth, the plant will not be so dependent on its surface roots, and consequently will not be so much affected if they are cut and injured during the processes of cultivation.

As regards the drainage of steep slopes, this is often looked upon as totally unnecessary, although the soil may be extremely stiff, and have great retentive power for moisture. It is not, however, merely the removal of water that is obtained by drainage, but also the aeration of the soil, which cannot be properly carried out on hill sides by the ordinary hoeing, as too much loosening of the surface soil causes the latter to be washed away by the downward rush of water. With drains placed almost horizontally round the hill, at short intervals, the water would in time tend to soak beneath the surface and reach the drains from below, while the amount of water that fell on the surface between the drains would be comparatively small, in fact not sufficient to run off, the rush of water down a hill-side being largely due to its accumulation from all over the upper surface. In the case of heavy continuous downpour for some hours, probably a certain amount of the surface soil would be washed down into the drains, where, owing to their being nearly horizontal, the rush of water would be checked, and the particles of soil would immediately settle in them, from which it could be again thrown up around the bushes without much labour.

METHOD OF DRAINING.—The usual system at present adopted is to have one or more main drains into which lateral drains, placed from 2 to 6 or more nulls apart between the rows of bushes, empty themselves.

These lateral drains are almost always placed at right-angles to the main drains, so that the water flowing from them rather tends to check that of the main drain, and to cause a deposit of silt on either side of their mouths. To remedy this the lateral drains should be made to enter the main drain at an angle with the direction of flow, either by placing them diagonally throughout their entire length, or curving them near their lower end.

No lateral drains should enter the main drain exactly opposite each other, as at present is almost invariably the case, for the flow of each one is thereby checked where they meet, and silt is deposited for some distance from their mouths, rendering the drains useless until cleared out. They should therefore be dug so that they enter the main drain alternately from either side.

In laying out land for drainage, it is necessary, first, to ascertain the lowest point from which the water can be discharged. One or more main drains must then be made running up the bottom of any hollows throughout the area to be drained, these being of sufficient size to carry off all the water of the heaviest rainfall.

The lateral drains must then be dug so as to cross the slopes diagonally, and enter the main drains in the manner described above.

As a general rule the width of the lateral drains need not be great; one hoe or about 9″ being generally sufficient; but this will depend on the character of the soil and the length of each individual drain.

On certain soils the sides of the drains will not remain perpendicular for any time after they are cut, the edges gradually crumbling away and falling in until a certain slope is reached, known as the "Natural Angle," which varies according to the lightness or stiffness of the soil.

Where old gardens are being drained, the narrower the drains the better; for if the bushes are planted rather closely, wide drains remove a good deal of the soil from either side of the adjacent rows, and thus cause a certain amount of harm.

The width apart that lateral drains should be placed is most important; for, if too widely placed, the intermediate soil is not completely drained, and if too near, the drains do not work to their full capability, and the extra expense incurred in making and keeping them clear is practically wasted.

The proper width is best determined by the character of the soil, clayey or stiff soil requiring them much closer and deeper than sandy, porous ones. For the former class of soils the drains should not be more than from 18 ft. to 24 ft. apart, and 3′ 6″ deep, and for the latter from 30 ft. to 36 ft. apart with the same depth.

It must be remembered that, by deepening the drains a few inches, the width of soil on either side that they will drain is increased by some feet, while on the contrary, when the drains are made shallower, or silt is allowed to accumulate in them, the area they will drain is considerably reduced: hence it is necessary to keep them always at their proper depth.

An average depth of about 3′ 6″ will probably in all cases be found most suitable, as beyond that depth, the cost of digging will be considerably increased, it being more difficult to remove 6″ of soil from below that depth than a foot of soil above it.

It is the practice on several gardens to bury prunings in the drains after they have been open some years, and to dig new drains between the next row of bushes, utilizing the soil removed to fill up the old drains. This burial of the prunings, the leaves of which contain a large amount of nitrogen, is no doubt of much benefit to the bushes in the immediate neighbourhood; but, if the drains have been dug originally the right distance apart, it would probably be found more economical to spread the prunings evenly and trench them in with a double hoe than to incur the expense of re-digging all the drains.

The question has been raised as to the possibility of using pipe drainage for tea, and so doing away with the open drains. Several advantages would be gained by its adoption, but there are also several objections to it, the most important of which is, that in the dry season the roots of the tea-bushes would certainly penetrate the joints of the pipes, wherever water was to be found, and rapidly choke the drain; and it would be very difficult to discover the exact spot where the stoppage had occurred, without opening the drain in several places throughout its length.

Vermin, white ants, &c., would also be liable to damage the drains, by excavating the soil below the pipes, when they would drop out of their proper level, and so prevent a free flow. In the case of such an accident the faulty spot would probably be shown by the water rising to the surface as a spring, during any very heavy rain-fall.

Under the present system of the hand cultivation, the drains being open is not of much importance; but, if animal labour is eventually employed for ploughing, &c., then the open drains would be a great inconvenience, preventing the free use of machinery of any description.

The sides and bottom of the drains should be cleaned regularly every year at the end of the rainy season, also any unusual accumulation of silt arising from some obstruction in the drain should be removed as soon as observed, for if this is neglected, it will be found that the whole length of a nearly level drain will rapidly be filled in to the depth of some inches, requiring much labour for its removal, which might have been avoided.

The soil which is removed from the drains at the time of digging, and when being cleaned, will be found of much benefit to the bushes around which it is thrown, both as a manure and as a means of checking the growth of weeds for a time. It should always be spread as evenly as possible at some distance from the sides of the drains so that the soil may slope towards, and not away from them, and care should be taken in hoeing, that a few inches of uncultivated soil should be left on either side of the drain to prevent the disturbance and falling in of the edges.

Clearing.—The amount of cultivation that newly cleared land receives before it is planted out, either with seed at stake or seedlings from nurseries, is generally not very great; the land frequently being only once deep hoed to break up the soil, and after staking, the soil, where each plant is to be placed, is pulverised, and any weeds removed with the hand. All the intermediate soil is left in a very rough state, which makes it difficult to hoe and clean properly when once the young seedlings are planted, without injury to the latter.

It would probably be advisable in most cases to clean and pulverise all the soil to a certain extent before sowing or planting, for it is only by such means that grubs, such as cock-chafers, &c., can be discovered and killed.

The damage that these insects do to new clearances, by biting through the young plants just above the ground, is often very great, and much time is lost unless the destroyed plants are immediately replaced with others. Seed planted at stake seems to suffer more than transplanted seedlings, owing to the grubs being able to attack them at a very early age when the slightest injury proves fatal; and I have seen large areas planted in this manner in which hardly a single plant survived, and the whole of the seed and season was lost.

A little extra care, therefore, in cleaning the land before planting will always prove beneficial in the end, as the extra expense incurred will be trifling compared with the cost of replanting, and the loss of time and labour, if the first seedlings are destroyed.

Sowing seed at stake appears at all times to be rather a precarious undertaking, and should never be attempted unless there is an ample supply of water near at hand in case of drought; and even then the expense and labour of watering a large area for some days or weeks is very great.

The soil above and close around the seeds can be kept moist for some time by covering with grass jungle, by which means evaporation from the surface is checked; but it is an endless trouble to keep it from being blown away or otherwise removed, and at the same time it forms a most suitable home for all grubs and insects which are likely to injure the plants.

If, however, the soil is free from grubs, and the season turns out a favourable one, a considerable gain in time results over the transplanting method, the plants not being checked by having their roots disturbed.

Two or three seeds are usually sown at each stake, and if they survive the effects of drought, insect attacks, &c., the extra ones are removed and utilized for filling vacancies, where other seeds have failed.

In both the black and green tea districts of China, large quantities of young tea plants are annually raised from seeds. These seeds are gathered in the month of October, and kept mixed up with sand and earth during the winter months, by which means they are kept fresh until the spring, when they are sown thickly in some corner of the farm, from which they are afterwards transplanted at one year old, having attained a height of from nine inches to a foot. They are planted in rows about four feet apart, four or five plants being put in each hole, but sometimes, when the soil is poor, they are planted very close in the rows, and have a hedge-like appearance when full grown. The young plantations are always made in spring, so that the rains, and damp moist weather at this season, enable the young plants to establish themselves in their new quarters, where they require little labour afterwards, except in keeping the ground free from weed.

NURSERIES.—The greatest care is necessary in selecting a site, and preparing the soil for a nursery, as the whole future of the garden depends on the character of the plants raised, it being most important that they should grow healthily and without a check throughout the first years of their life. It is well known how difficult it is to get plants that have been at all stunted in the nursery to flourish when they are transplanted; and although in some cases, and under most favourable circumstances, they do improve, the plants they form are never equal to those that have always grown in a healthy manner.

The essential requisites for a good nursery are: A good loamy soil, with porous subsoil, a certain amount of protection from the sun and strong winds, a low lying position, and the proximity of a good water-supply.

It is perhaps not advisable that the soil of the nursery should be of better quality than the rest of the garden or estate, as the seedlings would in that case deteriorate when planted out; but it is essential that the soil be perfectly clean, free from weeds and grubs, well cultivated, and drained in such a manner that all excess of water shall be completely removed; it should also be of sufficiently stiff character to hold round the roots, when the plants are taken up.

The soil itself should not be reduced to too fine a condition, as it will cake on the surface whenever the plants are watered, which would check their growth, unless the hardened crust was continually broken up. Before sowing, the seed is usually germinated as it has almost invariably been found to give more satisfactory results, owing to the rapidity with which tea seed loses its germinating powers. It should be sown in cool weather when the soil is slightly moist, but not *wet*, and if possible shortly before rain is expected.

If a drought occurs after sowing, and before the plants are well up, shading (either raised or on the ground) will be required to lessen evaporation. The former is most suitable for allowing the removal of weeds from the beds, and does not encourage grubs or insects, but the latter is cheaper. Both, however, should be removed when the plants are up, otherwise the shade would weaken them.

The most suitable width at which the seeds should be placed depends upon the jât of plant, and the length of time the seedlings are likely to remain in the nursery, but in any case over-crowding should always be avoided, as not only will the plants be drawn up and sickly, but the rootlets are very liable to damage in taking them up for transplanting. In Cachar and Sylhet for ordinary purposes the seeds are placed 4″ by 4″, and 6″ by 6″ when the plants are required for filling vacancies; in Assam the average distances are 8″ by 9″ and 10″ by 10″ respectively.

If the soil is of rather a stiff character, and requires drainage, care must be taken that the subsoil, removed from the drains around the nursery, is not thrown over the beds themselves, as it will certainly check the growth of the seedlings for some weeks.

When the period arrives for transplanting, only the really well-grown plants should be taken, as the sickly ones are almost certain to prove disappointing: the latter may be left in the nursery to see if they improve after the others have been removed, and should they do so, utilised at a later period for filling in any vacancies that may have occurred from accidental causes. Theoretically, transplanting should take place during wet weather, so that evaporation of moisture from the leaves may be minimised, until the roots have recovered from the change; but if the transplanting is done in the cold season cloudy dull days should be selected for the same reason.

In taking up the plants it is advisable to retain some soil around them, so that the fine rootlets may remain uninjured, and they should be placed in their new position with as little disturbance as possible. Should the main root become injured or twisted in any way, it should be cut off from just above the wound, as the plant is then more likely to recover.

In using patent transplanters for removing well-grown seedlings from nurseries, it will often be found on examination that the tips of what would be the lateral roots are cut, and even with other implements the roots are liable to be cut if the implements are inserted too close to the plants. This is specially the case when the seedlings are very close together in the nursery, injury of the roots in this case being almost unavoidable unless digging forks are employed, when it would be very difficult to retain a clod of earth round the roots.

If, owing to lightness of soil or other cause, this clod cannot be retained, extra care will have to be taken in the replanting. The holes dug to receive them must be of ample size, and when the plant is placed in position, the extremity of the tap root is first secured by a little soil and firmly compressed, then the other roots are carefully covered in their proper position, the soil being pressed down as it is added until the whole pit is full.

Tipping or even cutting down the plant to near its root is sometimes practised before or after transplanting; but, if cutting at all is done, it should either be some time before transplanting to enable the plant to recover, or, if after transplanting, not before the plant has become settled in its new site.

In any case hard pruning should only be done when the flow of sap is ceasing, so that the wound may quickly heal; for, if it is done shortly before the sap rises, the plant is liable to suffer considerably by an escape of sap from the still fresh wound.

Tipping is usually not attempted until the plants have reached a height of 2½′ to 3′; it may, however, be performed at any time of the year without much injury to the plant, its object being to form symmetrical bushes.

Seedlings that have sent out lateral branches in the nursery should never be cut low down, but others that have formed a long weakly single stem should be cut to within a few inches of the ground, to encourage them to send out laterals from a low level, and thus form a bush.

It will have been often noticed how the seedlings of a nursery differ in appearance, healthiness, and extent of growth, even when raised from seed supposed to be all of one jât—some will be fine healthy plants, while others within a few inches are poor sickly specimens. This difference is chiefly due to the varying quality of the seed, though occasionally it may be partly due to the attack of worms or grubs. An examination of the roots of the weakly plants will generally reveal the main root as a twisted mass just below the decayed or used up seed, and to plant out such could only result in disappointment. Even if left in the nursery after the large plants have been removed, they will never grow to any size, and the best plan would always be to have them rooted up and destroyed. Seedlings are usually planted out when from 12 to 18 months old, though sometimes younger, especially when they have made good growth and are going into rich soil. For steep teelas or shallow soils of a light description, good root growth is required before planting out, or the seedlings will be very liable to suffer from drought.

The site of an old nursery is always discernible in a Tea Garden even after many years, the plants always being poorer than the rest of the garden ; this is due to the upper 9″ to 12″ of soil having been removed with the seedlings when they were transplanted, leaving the poorer subsoil behind. Good cultivation, the burial of large quantities of green jungle, or dressing with bheel soil or other manure will be necessary to bring it back to its former state of fertility, and this should be done as soon as possible after the nursery is cleared, otherwise the spot is always an unsightly one on the estate, besides yielding very little outturn of leaf.

The distance at which Tea should be planted varies according to jât, soil, position, and district; but, as it is becoming more general to plant only good varieties either pure indigenous, or indigenous once or twice removed, an average distance of 4′ to 4′-6″ between each plant and row is now usually adopted. For very large kinds of indigenous bushes, 5′ or 6′ apart is sometimes considered necessary to allow of proper cultivation between them ; but such large plants are very difficult to pluck, owing to their width, and the height they attain towards the end of the season. On poor soils, or on elevations such as teelas, planting should be closer than on good, low-lying land, it should also always be done in the rains, to prevent loss from drought.

On the gardens in the Dibrugarh district of Assam, where the rainfall often exceeds 120 inches, the bushes are generally planted closer, and are smaller than those lower down the valley, where the rainfall only averages about 80 inches, and it is generally acknowledged that the system adopted in one district would not be a success if practised in the other. It is difficult to account satisfactorily for either systems, unless it is that the heavier and better distributed rainfall of Upper Assam tends more to produce leaf than wood, the plants requiring a larger area of evaporation to remove the excess of moisture; and, as the leaves would be closer together on the stems, the plants would naturally attain no great height.

FILLING IN VACANCIES.—This is one of the greatest difficulties experienced by planters, as it has almost invariably been found that the new plants do not take well, where tea has been planted before, and when surrounded by other bushes, whose roots have penetrated and partially exhausted the soil in every direction.

In most cases the plants have died out from some cause or other before the garden has been planted many years, but until comparatively recently, the regular filling in of vacancies as they occur has not been attempted. Old plants, unless killed by white ants, or failing to recover from the effects of heavy pruning, rarely die out.

The most frequent causes of vacancies in young gardens are: the planting out of weakly seedlings from the nursery, which have been raised from poor seed or injured by insect or blight attack; on undrained condition of soil—certain fungoids attacking the roots of the plants, the decaying roots of certain forest trees, white ants and wood-boring grubs, the careless hoeing by the coolies, when the young plants are surrounded with jungle, and the trespassing of cattle on the garden.

Most of these could be prevented by the adoption of special means suggested by the causes themselves, as the planting out of sound healthy seedlings only, draining where required, eradication of the injurious roots, and fencing before planting the land, owing to the difficulty experienced of replacing the diseased bushes, prevention would be better than cure, and means for this end should be adopted for all new clearances but, where the vacancies are in old gardens, the only remedy is to re-plant.

Most planters think it is better to open out new land, when it is to be had, than to go to the expense and trouble of filling the vacancies in the old gardens; but, where labour for cultivation is limited, the latter would be preferable.

On many gardens 10 per cent. of vacancies is by no means uncommon, and frequently it amounts to 15 or 20 per cent.; taking the first number however, it will be seen that, on a garden of 500 acres, there would be 50 acres unplanted, but which are hoed and cultivated several times during the year together with the rest of the garden, while the return from them is absolutely nil.

If 50 acres of new land are cleared and planted to make up for the above loss, and no fresh labour is imported, the less cultivation can be given to the whole garden, and the yield per acre over the whole area would almost certainly diminish.

Hence, it would be advisable to use every endeavour to fill all vacancies successfully; and, to do this, they should be refilled as soon as they occur, proper precautions being taken to remove, and if possible, prevent a recurrence of, the cause.

On a plant dying, it should be immediately removed from the soil, and the cause of its death ascertained. A large hole should then be dug from where it was taken, and the excavated soil allowed to remain exposed to the atmosphere for some time, and mixed with quicklime if any fungoid growth had been found.

Two or three baskets of cattle manure or rich bheel soil should be placed at the bottom of the hole, and covered with a little of the soil, a short time before putting in a new plant.

The latter should be of a somewhat similar jât to the surrounding bushes, about two years old, and well grown: it should be removed from the nursery with as much soil about the roots as possible during damp weather, and quickly placed in its new position, the greatest care being taken that the roots are not twisted or broken in any way, the limed soil should then be pressed firmly round, and a large stake or bamboo inserted to mark the spot. Should the weather become very dry, the plant would require an occasional watering; but if planted in the rains, this is not likely to occur. In any case, the transplants should be inspected by specially appointed men, until they have taken firm hold of the soil; the soil should also be hand-weeded for about a foot round each new plant, so as to prevent any damage from the use of the hoe. By this means the plants would soon be found to take a firm hold of the soil, and the manure beneath them would assist their growth. For some years, such transplants should not be pruned to a definite height with the surrounding bushes in the cold weather, but should be cut according to their requirements, the object being to form a sound, well branching plant as soon as possible. In their third year a little leaf would be obtainable from them, but plucking should then only be sufficient to encourage thickening of wood, and prevent the branches becoming long and weakly.

Colonel Money, in his essay on "The Cultivation and Manufacture of Tea in India," recommends sowing seeds for transplants in specially made pots, or placing young seedlings in bamboo baskets, and letting them grow until the following rains, when they are to be planted in holes as they are, the pots merely being broken *in situ* to allow the free passage of the tap and lateral roots. By this means the plants are said not to feel the change, but continue growing well, forming good plants, able to withstand drought before the next dry season. Special precautions in staking and weeding would be required to protect the plants from the hoe, and this is very difficult when the plants are very young and small at the time of planting out, six weeks' growth of jungle being more than sufficient to completely conceal them.

TEA SEED GARDEN.—In China the seed ripens in October and November and is usually sown immediately after ripening, several seeds being planted in one hole, as the greater part is always abortive. In the green tea district, however, they are mixed with sand and earth in a damp state, and kept until the spring, such preservation being necessary to maintain the germinating powers. (FORTUNE.)

In India the plant flowers usually in the autumn, though some may be found to do so all the year round, and the seed ripens about the same period of the year (October), and after cleaning, removing the outer shells, and sorting, they are germinated, or sown directly in nurseries, or at stake, as soon as possible. Tea seed which contains a large quantity of oil rapidly loses its germinating power, if kept for any length of time after being plucked, and the kernel contracting and becoming dry and shrivelled.

It is of the utmost importance for the future success of a garden that the seed employed for rearing the necessary plants should be of the best and soundest description, for, if otherwise, the plants produced will be weak and sickly, and no soil, however good, will be able to make them equal to those raised from sound seed. On many gardens a certain area is kept entirely for seed production, the bushes usually being raised from seed of an indigenous jât. This area is often situated near the leaf producing portion of the garden, where, in most instances, plants of inferior jât to the seed bushes are growing; consequently the seed from the latter will rarely produce plants of the same high jât as the parent bushes, since the flowers will have been fertilized in many cases by the pollen taken from the China or poorer hybrid bushes, which are continually flowering and producing seed.

The employment of such seed for further extensions or new plantations must result in a gradual deterioration of gardens generally, in class of plants, yield, and possibly in the value of the manufactured tea. It no doubt accounts for the large percentage of poor non-yielding bushes in many gardens of comparatively recent origin, no treatment, either of pruning, manuring, or extra cultivation, being able to bring them to a high state of efficiency.

Hence, in cases where seed is produced on an estate, the area reserved for the purpose should be as isolated as possible, and the bushes of the best procurable jât. It appears that the purest indigenous are not invariably the best for seed production for ordinary planting out. But plants raised from their seed, yield in their turn seed which produces a stronger and better plant with superior flushing qualities. The latter, therefore, which are spoken of as "indigenous once removed" are preferable for the seed garden.

The production of seed from the tea plant necessitates very different treatment to that required for the production of leaf, and also probably a rather different class of soil to produce the best results.

The production of seed by plants is looked upon as an effort of nature to reproduce the species, and to prevent their dying out. Plants that have deteriorated either from age, unsuitability of soil, injury, or other cause, always tend to produce seed, and this is evidenced in the case of tea by the prolific character of the aged China and poor hybrid bushes, also by the increased seeding properties of the lowest lateral unpruned branches of other jâts, especially when the plants are near a road or drain, where the branches and roots are more liable to injury. But seed obtained from bushes under the above circumstances are not likely to produce vigorous plants such as are necessary for the formation of a profitable garden.

The soil selected for a tea seed garden should have somewhat similar mechanical and physical properties to that for leaf production, *viz.:* depth, porosity, and good drainage qualities; but richness in nitrogenous organic matter is not so essential, as the latter tends to promote the formation of wood and leaf, rather than seed; it should, however, be rich in all mineral plant food especially in lime or magnesia, the former being well known to cause increased fruitfulness. Chlorides, chiefly chloride of sodium or common salt, have also the tendency to promote fruitfulness; and, as this constituent is generally deficient in most inland soils, an application of a few maunds of salt per acre might prove beneficial in cases where the bushes run to leaf instead of seed.

To obtain a large outturn of seed, little or no pruning would be given, but the bushes allowed to run up into trees with straggling lateral branches, towards the extremities of which the largest number of seeds would be produced; but, where quality as well as quantity is required, a certain amount of pruning should be given to obtain it. This pruning should always be light, and of a different character to that employed for leaf production, though the object in one instance is the same, *viz.*, to produce a large yielding area, and to assist in the formation of the tree or bush; but, in this case, the extremities of the branches do not require to be cut, only excessive wood and decayed matter removed from the interior of the bush, to allow a free current of air.

The bushes should be widely placed to prevent crowding and consequent drawing up of long, feeble, and useless branches, and to allow plenty of space for frequent deep cultivation. The latter is very important for seed production, and can be done at almost any time of the year, as for the latter purpose a certain amount of root pruning is usually beneficial and not detrimental as when leaf is required. But it should not be done while the soil is sodden with moisture, especially if the soil is of a heavy or clayey character, as the effect is exceedingly detrimental to growth of any kind, and to an extent far beyond what is usually believed.

In old seed gardens where the yield may be deteriorating, digging in green jungle, or cattle manure consisting largely of litter, would prove beneficial, especially if accompanied by a fair dressing of mild lime, which would hasten the decomposition of the organic matter.

PRUNING.

CHAPTER VI.

THIS subject would require several years' experience in different Tea districts, and careful attention to the annual climatic influences on the several varieties of the Tea plant before anything could be definitely laid down for general guidance. Very different treatment is required for the free growing single-stemmed indigenous plant and the many-stemmed China variety; also for plants of any jât, when growing at elevations ranging from 100 ft. to 6,000 ft. or more above sea level, and in climates, the rainfall of which varies from 60 inches to over 200 inches per annum. The character of the soil, prevalence of blight, temperature of the atmosphere, and the liability to hail-storms or drought would also affect the period at which pruning should be carried out, and the method to be adopted.

The main object of pruning Tea is, of course, the preservation of the health and symmetry of the bushes by removing all decayed or injured wood, to encourage flushing or the production of new shoots, and to form as large a surface for the latter purpose as possible.

In India it is almost invariably done in the cold season, or from December to February inclusive, the different varieties being pruned in the order they cease to flush, *viz.*, China first, then hybrids, and lastly the indigenous varieties, which often do not cease flushing until the beginning of the new year.

No pruning should be done until the sap of the bush has almost ceased to flow, but after that period, if early flushing is required, the sooner it is performed the better, as the bush will then be more ready to take advantage of the early rains and increase of temperature. It is generally acknowledged that plants, although apparently dormant through the cold season, are slowly accumulating plant food from the soil, and storing it up in their stems and branches; by early pruning, therefore, none of this reserve material is removed from the plant.

In Sylhet it is considered more advisable to prune late, as the district is subject to hailstorms and drought at the period of the year when early-pruned tea would have re-commenced flushing, and the young shoots would run the risk of being completely destroyed.

In Chittagong or any hill district, where the temperature in the spring is low, early flushes would be liable to be killed by cold, and the bushes would be thrown back for months.

In the Dooars or Terai late pruning is also said to be the most suitable, as the district occasionally suffers from drought in the spring, which would completely destroy any young shoots; and the only time when early pruning is advisable, is when blight appears late in the season, and has to be checked.

Early flushes also (the result of early pruning) are in many districts frequently affected with red spider or other blights to which the later flushes are not so subject, hence late pruning would be advisable in these districts.

One other objection to early flushing is, that the bushes tend to close earlier in the season, unless the climatic conditions during the latter half of the year are exceptionally favorable to growth; and as the first teas manufactured are almost invariably poor in flavour and strength, the advantage of early production is very small. Hence, it is evident that the period of pruning must be largely regulated by local conditions, and this is especially necessary when a heavy pruning, *i e.*, cutting down almost to the ground, is to be given, for the following reason: the destruction of an early flush on a *lightly* pruned bush is not of such very great importance, as there is plenty of wood with numerous axils from which new shoots can be formed, and the first flush rapidly replaced without much injury to the plant; but when the first young shoots of a *heavily* pruned bush of the indigenous or good hybrid variety are in any way injured or destroyed, the plant is permanently damaged, or at least for several years, as hard knots are certain to form in the young stems which form the base of future pruning, and the free flow of sap is prevented.

The age at which plants should first be pruned varies in different districts from 2 to 3 years, but this is more frequently regulated by the amount of growth, for instance, in Cachar and Assam it is usually done when the young plants have attained a height of from 3 to 4 feet, and in the Dooars from 5 to 6 feet. In Assam it is frequently recommended to cut down the young plants to a height varying from 6 to 9 inches as soon as they have struck well after transplanting: in Chittagong to prune to 13″ all bushes that have fairly thick stems at the age of 3 years from seed: and in the Dooars to cut down to 14″ in the first, second, or third year. These various heights have, no doubt, been fixed from the result of experience, but it is very difficult to say why one should be more beneficial than another, unless it is the prevalence of a different jât of plant in the three districts.

The main question to be solved as regards the pruning of the plants in their young stage is, what method should be adopted to produce the most satisfactory form of bush for yielding purposes? The formation of good straight wood in the stem or stems would be the first consideration; on a good free soil, and with plants raised from sound seed, pruning would be unnecessary, until the required thickness at the base of the stem had been obtained, for the plants would grow in a perfectly symmetrical manner, the wood increasing in diameter as it gained in length; but on a poor soil, or a soil unsuitable for tea from want of drainage, &c., or with plants raised from seed of indifferent quality, the growth would be slow and unhealthy, resulting in the formation of a hard and bark-bound stem, which would have to be cut away, and the other defects remedied, before healthy growth could result.

The pruning of young bushes is generally upwards, *i. e.,* the cut is made above the previous year's pruning for the first few years; then pruning downwards (the reverse to the above) is adopted; until it becomes necessary from the knotted and hard condition of the wood to prune close to the ground, and form new growths from the surface of the soil.

This latter kind, known as "heavy pruning," is a great strain on the bush, and extra assistance must be given to enable it to recover. If the main stems are of large diameter, a saw is usually employed for cutting off the bush; but whatever is used, the cut should be in a sloping direction to prevent lodging of water and consequent rotting of the roots.

The sap must invariably be dormant when this is done, as a large cut surface is exposed, from which the bleeding would be very considerable if the sap was flowing.

Occasionally the upper portion of the stem is tarred or dressed with the ordinary petroleum or earth-oil, which would tend to preserve it; but the main thing required is good deep cultivation without injuring the roots, and a heavy dressing with good bheel soil, or cattle manure.

If this is done, scarcely a single plant will be lost, and the new wood formed will be straight, sound, and thick, producing bushes superior to the former ones, as there will be now several channels for the rise of sap to the leaves.

Such bushes are frequently left unpruned during the cold season following a heavy pruning, which assists in thickening the new stems, and makes them more suitable for pruning on the following year. It is not always necessary, however, where the growth has been very rapid during the season, as the wood will be sufficiently thick for all practical purposes.

Returning to the pruning of young well-grown bushes, it is usual for the main stem to be cut down to the various heights given above, but the branches are left uncut, or merely tipped, to encourage lateral growth. In the following year the whole bush would be pruned to a height varying from 18 inches to 2 feet, and so on, until the desired size of bush had been attained, or the necessity of pruning downwards had arisen from the knotted state of the stems. Every year all damaged wood must be removed from the bushes, and the latter kept as open in the interior as possible, to admit sufficient air and light for the healthy growth of the plant.

The lowest straggling branches of the bushes should be removed annually, as they yield no leaf, the extremity merely becoming barjy, and by leaving them the production of seed is encouraged, greatly to the detriment of the flushing qualities of the bush, as the latter will not readily produce both fruit and leaf, large quantities of the mineral plant food becoming stored up in the seed for the use of the future embryo. Their presence also shuts out the air from the soil, and increases the difficulty of cleaning and cultivating the latter beneath the plants.

For the many-stemmed China varieties the pruning is usually harder than for the indigenous and best kinds of hybrid, and their plucking surface is usually kept at a low level. As far as possible, the cut should always be made just above a bud, but it is very difficult to insure this being done, as the work has to be performed by numbers of coolies, who would require continual watching. Fairly late pruning is considered the best for promoting a continuous flushing through the following season, as with early pruning there is frequently a great rush of leaf early in the year, resulting in the formation of comparatively thin weak wood, and an early cessation of yield.

Whatever system of pruning is adopted, however, the yield depends almost entirely on the climatic conditions and character of the soil, and a system that might produce excellent results on a portion of a garden one year, would, if adopted the following year under different climatic influences, produce entirely opposite results.

On several estates there has apparently been a tendency to under, rather than over, prune for several years, and the result has been very detrimental to the bushes, greatly reducing their vitality and flushing capabilities. Cutting down to the ground is in such cases what is needed; but, unless accompanied by heavy manuring, several of the bushes would inevitably die out.

All knives, &c., used for pruning, should be kept very sharp, as a clean cut does much less damage to a plant than a partial cut and fracture; and, although the actual damage to an individual bush is small, yet, when spread over a large estate, it becomes very considerable.

The means adopted for the disposal of the prunings has usually been to bury them, and this, if done deeply and thoroughly, and while *fresh,* is no doubt the best method, as the leaves are very rich in nitrogen, and make excellent manure. If not thoroughly done, however, and the bushes were blighted, it is liable to cause a recurrence of the attack in the following year; consequently, if the prunings are large, and not easily buried in the ordinary trenching or double hoeing, they should either be buried in specially-dug trenches, or burned to destroy every trace of the blight.

PLUCKING IN CHINA.—The Chinese are perfectly aware that the plucking of the young leaves and shoots is very prejudicial to the health of the tea-shrubs, and always take care to have the plants in a strong and vigorous condition before they commence gathering.

The first plucking is not done until the plants are two or three years old, well established in the ground, and are producing strong and vigorous shoots; even then weakly bushes are passed over altogether, in order that their growth might not be checked. Plantations under the most favorable circumstances, will not yield profitably after they are ten or twelve years old: and they are often dug up and replanted before that time. [1]

In the green tea districts of Chekiang, there are only three crops of leaves taken during the year. The first is generally gathered

[1] Tea Districts of China and Japan, p. 258.—Fortune.

about the middle of April, consisting of the young leaf buds just as they begin to unfold, and forms a fine and delicate kind of young Hyson.

The picking of the leaves in such a young state does considerable injury to the tea plants; the summer rains, however, cause a second flush about a fortnight or three weeks after the first, and the second gathering, the most important of the season, takes place.

The third and last gathering is done as soon as the new leaves are formed, but produces a very inferior kind of tea.[1]

Mr. Ball mentions a fourth gathering of the coarse leaves in September and October to form the common Bohea, in which whole branches are cut, and the leaves stripped off. The leaves are coarse and stiff, and the flavour exceedingly common and bad.

The mode of gathering the leaves varies according to the succulency of the shrubs, and the practice of different localities. In situations where the shrubs produce long succulent green shoots with many leaves, the leaves are pinched off in pairs with part of the shoot, and classed at the time of gathering; or the whole shoot may be gathered at once and the leaves plucked off, and classed afterwards by females, when received at the roasting sheds. The Hyson leaves are said to be so gathered, and the stalks and shoots are separated carefully, because the stalks would injure the tea in the progress of manipulation: but with black teas, the stalks and shoots seem to be separated with less care, because attended with no apparent detriment to quality.

A Chinese manuscript gives the following account of the qualities of the different gatherings of the Congou tea, which forms the bulk of the black tea imported into England: The first gathering may be divided into superior, middling, and low; the superior kind resembles the Souchong tea in flavour and colour. The second gathering also produces Pekoe and Souchong; the flavour has a fire smell, and the leaf is coarse and dull. The third gathering also produces Pekoe and Souchong, though not much, neither is it good, the flavour is poor and the infusion of a light green colour.

The autumnal or fourth gathering—August and September—the flavour is poor, and the infusion of a pale yellow colour; the colour of the leaves is also plain and ordinary.

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[1] Wanderings in China, 191.—Fortune.

Now, it is obvious that one great cause of difference in the quality of tea depends upon the time of the year in which the leaves are gathered. Thus, the Chinese universally agree that the young luxuriant leaves put forth and gathered in early spring are the best, while the other gatherings deteriorate in quality as they approach the autumn, which are the worst.

Mr. Ball explains this by saying that "the sap is in a more concentrated or inspissated state from its accumulation during winter, than subsequently, after its first and most vigorous flow in early spring."

The experience of Indian planters does not tend to confirm this, as the first tea made is usually poor in strength and flavour, but it gradually improves throughout the season instead of deteriorating.

Mr. Jacobson states that in Java the gathering is divided into three classes of leaves, and each class is gathered by different men. First, the top-leaf, consisting of the convoluted leaf bud, with its expanding or expanded leaf; then the fine leaf tea, consisting of the second and third leaves; and finally the fourth and fifth leaves, which form the middle leaf tea. The coarse leaf tea is the refuse of these two classes after manipulation. It is the duty also of the gatherers of the middle-leaf tea, as they are the last gatherers, to search for and gather any other delicate leaves which may have been overlooked by the previous gatherers. The mode of gathering is by turning the thumb downwards, and nipping off the young green succulent shoot with the nail and forefinger, first below the top-leaf with its expanded or expanding leaf, then below the second and third, and the fourth and fifth leaves. If the sixth and seventh leaves are fit for tea, they may be gathered also.

When the last leaves on the shoot are gathered, they must not be nipped off, but plucked upwards, and in such a manner as not to injure the buds: otherwise such shoots or branches would be left without the power of reproduction. It is desirable that *two*, but not more, buds should be left on each shoot.

After the fourth gathering, the shrubs will once more exhibit an abundant display of foliage, but these leaves must be left to restore the exhausted energy of the plant. [1]

PLUCKING IN JAPAN.—The tea plant bears leaves ready for plucking in its third year, and it is considered at its best from the

[1] Cultivation and Manufacture of Tea.—Ball.

fifth to the tenth year. But age does not deteriorate the plant, the only difference being that with years it requires more manure. The shrub is not allowed to grow beyond a height of three to four feet, necessary both for the convenience of picking, and for the strength of the new shoots.

As the season is early or late, the first picking commences at the latter end of April or beginning of May, and lasts about twenty days or a month. The second crop is gathered in June and July, and sometimes a third one later on. This work is performed almost entirely by girls, who deftly pick off the new leaves, but very often also the whole of a new shoot, so that long stems are frequently met with in their baskets, where leaves only should be seen. At each of the gatherings the leaves are larger and coarser than the former, and are used for the manufacture of a lower grade of tea.[1]

The Japanese also make a fourth plucking, taking pretty well what is left on the trees for their own private use, that is, when the foreign demand at a remunerative price is equal to the crop from three pickings.

There is a great disparity between the size of good Assam hybrid leaves and those of the varieties of tea cultivated in Japan. The former produces leaves varying from five to ten inches long, but the larger leaved variety of tea cultivation in Japan, me'cha, is only two inches long, while the smaller variety, o'cha, has leaves, the largest of which is little more than an inch; the flush is of course small in proportion.

PLUCKING IN ASSAM (INDIA).—According to Bruce the plucking season in Assam generally commenced about the middle of March; the second crop in the middle of May, and the third crop about the first of July, but the time varied according to the rains setting in sooner or later. Two or more leaves were nipped off at one time by the finger and thumb, which is also the general practice now.

The ideas on plucking are many and varied, and much has been written on the subject since the commencement of tea planting in India. Some have advocated one method, and others an almost entirely opposite one, both giving valid reasons to justify their processes.

The age at which plants are first regularly plucked also varies in different districts, but usually at three years; a light tipping being sometimes given at two years to assist in the formation of the bush.

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[1] Trans-Asiatic Society of Japan, Vol. XII., Part I.

There are some who recommend hard plucking at the commencement of the season, and others who say pluck lightly at first, and gradually pluck harder as the season progresses.

The number of flushes during the season averages 11 or 12, and after a light pruning, the first is allowed to grow about 6 leaves before plucking commences, when the top two or three are taken, the second flush to grow about 5 leaves, and so on.

Pluckers go round the garden about every eighth or tenth day to take all that is ready, which secures the leaf from getting hard, or from growing past the flush period, and also ensures the whole produce in leaf of the best quality.

A contested point has been, whether it is better to pluck two or three *whole* leaves and the bud as the case may be, or to pluck two and a half or three and a half, and half the one below if soft, leaving the axils of the third and fourth leaves and the internode or stalk between them. A planter, who had given both systems a fair trial for years, advocates the latter ; his reasons being:—

1°. The rapidity with which the next flush comes on.

2°. The absence of unsightly stalk in the tea.

3°. The greater facility in sorting the roll before fermentation and separating the fine from the coarse leaf, so as to be able to treat each according to its requirements.

The first reason is the most important, as the difference in yield is very marked. By leaving a whole leaf below, the sap of the plant goes to mature it before the new shoot breaks away, whereas by leaving the axil with a small portion of the third leaf, the sap of the plant goes directly to nourish the young shoot. If a whole leaf is left, this maturing process goes on repeating itself after each plucking, always delaying the new flush, and retarding the growth of the plant. At the beginning of the season, when the bush is recovering from its pruning, it is most marked, five weeks having been known to elapse between a first plucking and the second, while bushes plucked two and-a-half leaves have gone on growing without a check.[1]

Plucking in Ceylon is closer and more frequent than in India, the rate of growth being far more rapid, especially in the low dis-

[1] Tropical Agriculturist, Vol. II., 1883, p. 960.

tricts, where it is found that if the Indian method of plucking was adopted, the tree would make so much wood and leaf that (nature being satisfied) it would cease to flush.

It will be noticed that the rate of flushing has largely increased since tea-planting was first commenced.

The China bushes introduced by Gordon and Fortune, and planted in the North-West Provinces, only yielded three flushes at first as in China, but the number has now greatly increased.

The indigenous bushes of Assam only yielded four flushes at first according to Bruce, but careful and heavy pruning, together with good cultivation, under most favorable conditions of soil and climate, have given rise to the good flushing qualities which all classes of bushes now possess, but more especially the indigenous and high-class hybrids. Experience has taught planters that heavy plucking at the commencement of the season or from young bushes is exceedingly detrimental. Mr. Fortune in his inspection of the Himalayan gardens, remarked that in several of them the bushes had been much injured by over-plucking. Light plucking at first, *i.e.,* taking only a few immature shoots as they attain a certain height, favours the bushes by allowing the formation of wood for yielding heavier flushes later on ; but its continuous adoption would injure the bushes by causing barjiness, unless under the most favourable conditions of soil and cultivation.

Two leaves and a bud are now commonly plucked at a time, but occasionally the third leaf is taken. No difference is made as regards jât, all kinds being plucked alike, except that the poorer classes of hybrid and China are harder plucked than the indigenous.

At the commencement of the season the shoots of the first flush are allowed to grow five or six leaves, before the youngest two and unopened leaf-bud are plucked, the extent of growth allowed being regulated by the state of the bushes, and the kind of pruning it is to receive at the end of the season.

If a bush has been heavily pruned, the object of the planter is to form good new wood during the first year, rather than to obtain all he can from the bush ; for this purpose plucking should be, and is delayed long into the season, the main shoots being allowed to attain a good height and size before being tipped. After the first tipping, which will have the effect of strengthening and thickening the main stem, as well the minor branches arising from the axils of the leaves low down in the plant, it will also cause new shoots to spring from the axils of the leaves just below the point from which the young leaves were removed. The plant should then be left until the minor branches have attained a length almost equivalent to the first main stems, when they also should be tipped with the same effect. At the end of the flushing season, the small shoots at the end of the branches should not be plucked, but left until the following season, when they would be the first taken, and followed by the other shoots as they attained a certain height.

Good effects have been found from leaving the bush unpruned the season following a very heavy pruning, not by an increased yield of leaf during the following year, but by the formation of better, straighter wood for pruning on for many seasons to come. Impoverished tea is always benefited by it, especially when supplemented by draining, bheel soiling, or manuring; hard plucking also can be commenced from the beginning of the season, the leaf yielding a stronger liquor than usual. It has certain disadvantages however as flushing ceases early in the season, and poor hybrid and China bushes have a greater tendency to produce seed.

For bushes that are full of sound wood and are of medium height, the object of the planter is to obtain the greatest possible quantity of leaf without detriment to the bush, and to assist in the strengthening of the wood already formed, and the formation (if the bush is thin) of some new wood from near the ground.

As in this class much new wood is not required high up in the bush, hard plucking can be resorted to, since the large number of twigs formed thereby will be removed in the following pruning, the young shoots for the following season being grown from lower down the stem, and this system can be followed until the vessels of the main stems have become hardened and choked by the deposition of ligneous and mineral matter, and the free flow of sap is prevented, by which time the bush will require a severe pruning, which will remove the old and useless wood from close to the surface of the ground. During the final season before the heavy pruning is given, the bush can be plucked very hard, every young shoot and tip being removed towards the end, there being no necessity for leaving anything for the formation of wood.

Most bushes vary considerably on the same garden, as to the length of stalk formed between the axils of the leaves, this being particularly affected by the bush growing in the open, or under shade, the intermediate stalk or "internode" being very long in the latter case owing to the drawing effect of the shade. Plucking in such cases should never exceed two leaves and the bud, as the long stem between the second and third leaf makes the manufactured tea very unsightly, unless it is carefully removed in the sorting. As, if the third leaf is plucked, the internode would be equal to at least one-sixth of the weight of the shoot, one-sixth of the daily labour, fuel, &c., employed for the manufacture would be wasted, as the dried stem would be useless in the tea, and only lower its value if retained. Where there is much shade in a garden, or other cause, whereby the young shoots are unduly lengthened, plucking must be done about every sixth or seventh day (two leaves and the bud being taken) to prevent the bushes attaining such a height, as to be beyond the reach of the coolies before the end of the season. If this is not done, it will be found that the young shoots arising from the axils of the leaves on the long and weakly stems, will at every plucking become more and more feeble, and the wood formed for the following year will be very poor.

Weekly pluckings of two leaves and a bud will result in a much larger proportion of tip in the tea, than if the pluckings are less frequent; plucked in this manner the two young opened leaves of the shoot are not even fully mature, and the leaf just below the bud still retains many hairs on its under surface, so that in the manufacture, when rolled, it appears almost like the tip, the hair on which gives the well-known silvery or golden colour to the tea.

The plucking of the third leaf is usually regulated by the demand for fine or coarse tea in the market; but if the pluckings are frequent, and the plants flushing freely, the third leaf would be too young and tender to make the teas much coarser, and it would probably equal in appearance tea made from two leaves and a bud plucked at intervals of 12 to 14 days.

On comparing chemically the tea produced from fine and coarse plucking, it has been found that the former has a higher total extract and more tannin, while the theine is about the same in both. It appears therefore that part of the tannin, which is one of the first products formed in the leaves from the carbonic acid and water absorbed, is rendered insoluble ; such is no doubt the case, part of the tannin forming an unstable, and insoluble compound with the albuminoids in the leaf, and part being converted by oxidation into an insoluble substance allied to the resins. As tannin is the chief source of the strength of tea, the advisability of plucking young leaf is apparent, when thick liquoring teas are required.

The lower percentage of tannin in the older leaves, however, is not only due to the above causes, but also to the presence of a larger proportion of cellulose and lignose matter, which are the ultimate products of the chemical changes in the leaf, and as the latter increase, the total soluble matter decreases in equivalent proportion.

MANUFACTURE.

CHAPTER VII.

The following description of the method adopted in China is given in Ball's "Cultivation and Manufacture of Tea:"

"After the leaves are gathered, spread them upon flat trays, and expose them to the air: toss them with both hands, sift them, and carefully examine them with a light to see if they be spotted with red, which is necessary. Carefully put them into small bamboo trays, and cover them up quite close with a cloth, until they emit a fragrant smell. Hand them to a roaster, to roast in a red-hot iron vessel. Throw about five ounces of leaves into the vessel, then with a bamboo brush sweep them out. Let them be well rolled, and afterwards sent to the drying-house to be completely dried. The Chinese seem to agree that the finest Souchongs, when made under favourable circumstances, would be injured by any exposure of the leaves to the sun. But these teas are made from the finest shrubs, the young leaves of which are large, of great succulency, as well as extreme delicacy, and are only gathered after a succession of bright weather, and the best kinds during the greatest heat of the day.

"On the other hand, leaves which are gathered from shrubs of inferior delicacy, and are somewhat harsh and fibrous in their texture, may be greatly improved by exposure to the sun, especially when gathered after or during rains.

"Indeed, leaves which are gathered during rains, or in cloudy weather after much rain, must be dried before or over a fire previously to their being roasted."

Black Tea.—When the leaves are brought in, they are thinly or thickly strewed on bamboo trays and placed in a shady position, where they are exposed to the wind or a draught for *a considerable* time. The finest teas are thinly strewed over the trays, but inferior kinds are placed five or six inches thick, and are kept in this state until they begin to emit a slight degree of fragrance. The leaves are then tossed and lightly patted by workmen three or four hundred times until they become soft and flaccid, when they are thrown into a heap and allowed to lie in this state for about an hour or perhaps a little longer. According to Mr. Ball, after the tossing operation, the leaves are sometimes pressed with a slight degree of force into a heap or ball. In both cases, they were kept until they emitted, what the workmen deemed, the necessary degree of fragrance, when they were roasted.

The finest kinds of Souchong teas require no tossing, but are simply whirled round and shaken to and fro, the process being continued at intervals until the leaves give out the requisite degree of fragrance.

According to some Chinese these teas then undergo another process previously to their being roasted, which consists in placing the leaves in heaps on sieves and covering them with a cloth, until they have become spotted, and tinged with red, when they also increase in fragrance, and must be instantly roasted, or the tea would be injured.

This state of withering is indispensably necessary to all black tea, and on the skilful management of this process the excellence of quality of all black tea depends.

The leaves are then roasted in thin iron pans heated by wood fires, until the leaves give out a fragrant smell and become quite soft and flaccid, when they are in a fit state to be rolled, which is done immediately on trays of bamboo work, a circular motion being given and a slight degree of pressure.

When sufficiently rolled, the ball is shaken to pieces, and the twisted leaves are spread out on trays for some time, when they are again roasted over a charcoal fire with diminished heat, and then rolled. These operations are repeated a third time, when the substance and good quality of the leaves admit of it.

No measure of time can be given by which the necessary degree of roasting can be determined, but a simple rule is, that " when any juices can no longer be freely expressed in the process of rolling, the leaves are then in a fit state to undergo the final desiccation. The final roasting is done over a bright charcoal fire, the leaves being spread one inch thick on sieves placed in tubular baskets, narrow at the middle, and wide at both ends. An aperture is made in the centre of the leaves, to allow the escape of any smoke, which may accidentally be formed, and a flat bamboo tray is placed over the top of the basket.

After half an hour the leaves are turned and the drying continued (the heat being greatly reduced by covering the fires up) until the tea is perfectly dry.

The black colour is now fairly brought out, but improves in appearance afterwards. When sufficiently crisp the leaves are sifted and the residue again put over a very slow fire for two hours. The tea is then packed in chests or baskets for sale.

PEKOE TEA.—"The Pekoe tea consists of the unexpanded terminal leaf bud, in which state the convoluted part is covered with a white hair or down.

"The manipulation of this tea is thus described: After the leaves are gathered, they are spread out on flat bamboo trays in the air to evaporate the watery juices, they are then roasted once over a slow fire, spread out again in trays to cool, and are afterwards dried in a basket as before. They require no rolling. Most Chinese say that the newly-gathered leaves are first placed in the sun, and afterwards in the air to cool."

Mr. Jacobson states that Pekoe tea requires much exposure to the sun previously to roasting; it should also be placed in close rooms, and not exposed to the air, but kept warm, because it is advisable to hasten and promote the withering of the leaves.

GREEN TEA.—There are only two gatherings of the leaves of green tea: the first begins about the end of April, and lasts ten to fifteen days; and the second at the summer solstice.

The leaves must be roasted as soon after gathering as possible, all exposure to the air is unnecessary, and to the sun injurious, since the veins of the leaves become red, and the flavour is injured.

If roasting cannot be done at once, the leaves are thinly strewed on tiled floors, or on flat bamboo trays in shady places, and turned when they show the least disposition to heat or ferment and turn yellow.

The leaves are roasted in a deep iron vessel over a brisk wood fire hot enough to produce a crackling noise in the leaves, which are kept continually stirred and shaken apart until they become quite moist and flaccid. They remain in this state about four or five minutes, and are then quickly drawn out and rolled to get rid of a portion of the sap and moisture, and at the same time to twist the leaves. When the leaves have a good twist, they are again roasted over a slow and steady charcoal fire, as soon as possible after the rolling. They are continually stirred about and fanned until the leaves become tolerably dry, and have assumed a dark olive colour almost black. They are then sifted and the roasting process is repeated a third time, but over a very slow fire, the heat of the pan being reduced to that degree, which the hand can bear for some seconds without inconvenience. During this final firing the leaves gradually assume that bluish tint, resembling the bloom on fruit which distinguishes this tea. This colour is not produced until the leaves are properly dried.

It will be observed that the chief differences in the manufacture of green and black teas are as follows:—

For green tea—

1°. the leaves are roasted almost immediately after they are gathered; and

2°. that they are dried off quickly after the rolling process.

For black tea—

1°. They are allowed to lie spread out for some time before they are roasted.

2°. They are tossed about until they become soft and flaccid, and then left in heaps, also before they are roasted.

3°. After being roasted for a few minutes and rolled, they are exposed for some hours to the air in a soft and moist state.

4°. They are at last dried slowly over charcoal fires.

MANUFACTURE IN INDIA.—The first teas manufactured in India were made in the same manner as those in China, Chinese workmen having been imported for the purpose, and to teach others the methods usually practised.

All the processes were carried out by manual labour, none of the labour-saving appliances now in use being at that time known. But gradually it was found that the many operations or processes formerly considered necessary, were not required, and they are now greatly reduced in number; while at the same time various machines were introduced, which were gradually improved upon until they reached the high state of efficiency which they now possess.

Colonel Money in his prize essay on *The Cultivation and Manufacture of Tea in India* gives a short statement of the old and new systems of manufacture, which illustrates the great saving in time, labour, and expense since the adoption of the latter. In this the number of days required for the manufacture is reduced from three to two, and the number of operations from twelve to five.

To arrive at a conclusion as to which of the numerous operations were necessary and which unnecessary, a large number of experiments were made with the several operations with the following results:—

WITHERING.—Unwithered or underwithered leaves break in the rolling and give out large quantities of a light green-coloured juice during the same process.

The tea is much broken and of a reddish grey colour. The liquor is very pale in colour, cloudy, weak, soft and tasteless.

Overwithered leaf, on the other hand, takes a good twist in the rolling, gives out but little juice, is of a thick kind, and of reddish yellow colour. The tea is well twisted, chubby in appearance and blacker than ordinary. The liquor of an ordinary depth of colour, clear with a mawkish taste.

Medium withered leaves made good tea, but the withering should be rather in excess of what is generally done to ensure strength.

Withering with the aid of heated air drawn over the leaf by means of large revolving fans is now about universally adopted on tea estates. It is specially useful for rainy weather, when it is difficult to obtain a good wither by ordinary means, the temperature of the air employed, being 80 to 85° F. if dry, or 90°F. if moist. Several forms of rolling machines are in use; which turn out the leaf, with almost as good a twist as was formerly obtained by hand rolling, and with a great saving of labour and time.

ROLLING.—Hard rolling gives darker coloured and stronger liquor than light rolling, but it destroys the colour of the Pekoe tips by the expressed juice. In all, therefore, but the point of Pekoe tips, hard rolling is better.

PANNING—Was found to be unnecessary, therefore a second rolling was not required.

SUNNING—Between the fermenting and the firing processes, has no effect whatever on the liquor, or the outturn, but it makes the tea rather blacker, and as it drives off much of the moisture in the roll, the firing process after it is shorter, and does not consume so much charcoal.

FIRING.—The operations of 1st firing, cooling, and crisping, and 2nd firing were found to be unnecessary, one final firing yielding the same results with a saving of time and charcoal.

The old methods of firing have almost entirely been superseded by the use of different machines, the principle of which is to draw a current of air heated by a furnace through or over the leaves, a draught being caused either by means of long chimney flues, or by revolving fans worked by water or steam power.

The high temperature employed in these machines has been thought to cause a loss of flavour in the tea, by partial dissipation of the essential oil, and a new machine has been invented, on the principle of drying at a lower temperature with a more powerful air blast, but with no very beneficial results. Sifting is now done chiefly by machinery.

WITHERING.

A great deal has been written about the various systems of withering adopted in India and their respective advantages, but good tea can be made from almost any system, provided the temperature employed is not too high, or, in the case of natural withering, the process is not too much prolonged.

The advantage of artificial withering, that is, the employment of some means to promote the passage of a current of air over the leaf, consists entirely in its enabling the planter to wither leaf in any weather, and so prevent loss either of the leaf itself, or in the quality of the tea produced from leaf which has been allowed to lie over for more than one or two days.

There is little chemical change in the leaf during the process of withering, beyond the loss of a certain proportion of the moisture contained, and consequent concentration of the sap; but if the leaf is at all bruised or injured, so that the air can gain free access to the sap, a process of oxidation and decomposition sets in almost immediately, and causes a loss in the appearance and quality of the tea. In sound leaf, the ccmmencement of chemical change can be observed at the end of the broken stem, where the constituents of the sap become oxidised, and gradually pass through stages of colour from coppery and dark brown to black. The amount of moisture which should be allowed to evaporate varies considerably, according to the jât of leaf, the time of year, and the weather, but about 33 per cent. apparently yields the best results.

The chief object is of course to obtain the leaf in a suitable condition for rolling, this condition being attained when the leaf will take and keep a good twist, without being fractured, but another important point to be observed is, that the sap must not be too concentrated, for the following reasons:—

1° The contents of the cells of the leaf will have contracted, so that the cell walls will tend to collapse instead of burst when the leaf is rolled.

2° A portion of the contents of the sap will have been deposited from solution owing to the concentration.

3° There will not be sufficient sap to be exuded over the whole surface of the rolled leaf, and the colour obtained during the oxidation process will be uneven.

Properly withered leaf has a soft feeling, and will retain its shape when compressed in the hand, and the youngest stems will bend without breaking, but it is impossible with the usual system of plucking, *i. e.*, two leaves and a bud, to get the second leaf and thickest end of the stem to wither as quickly as the bud and upper leaf, so that a certain medium has to be aimed at.

The objection to rolling leaf under-withered is due to its breaking in the process, and also to the large amount of sap expressed from the coarser leaf discolouring the tip, and giving the finer teas when sorted, a dull appearance, and coarse, pungent flavour and taste; while with over-withering, although a tea with a fine appearance is obtained, the liquor has lost in pungency and strength.

The temperature employed in artificial withering should never exceed 100° F., and even this should be reduced to 85° F., or less when the leaf is nearly ready; but at the commencement, when the leaf is either very wet from rain, or contains an excess of moisture from rapid flushing, the above temperature is found to do no harm to the leaf, probably due to the fact of the rapid evaporation causing a reduction in temperature of the leaf itself, to several degrees below that registered by the thermometer in the withering chamber, but if this temperature were continued until the leaf was withered, it would result in the *drying* of the finer leaves before the stems, &c., were ready.

I do not think it matters much what material is used for withering the leaf upon whatever process is adopted; but fine galvanized wire netting allows the best circulation of air, and therefore gives a more rapid wither. It is, however, very expensive, especially when made into trays, as by the constant handling of the latter, the wire soon becomes broken in places and constant repairs are needed; it is more lasting when stretched between posts on wires, and the leaf is shaken off it by tapping underneath.

When withering is done on large chungs, cloth is the best material to be used, as the leaf when withered is easily collected by rolling up the cloth from either end.

To obtain a natural wither it is necessary to spread the leaf far thinner than for an artificial wither, consequently a larger area is required.

A good deal of judgment is necessary to know how to spread in order to obtain a succession of properly withered leaf for the rollers; if all is spread thinly at once, the whole amount will be ready at one time, and part would thus be over-withered before the rollers would be ready for it, or if the leaf brought in during the middle of the day in hot dry weather was spread thinly at once, it would probably be ready before the morning. No hard-and-fast rule can be laid down, as it must be regulated by the amount of rolling machinery available, as well as by the weather. When the leaf is brought in from the garden heavy and wet with rain, it is important that it should be dried as soon as possible, as withering proper apparently does not commence until this extraneous moisture has been removed. Wet leaf always has a hard brittle feeling when first brought in, which only disappears when the leaf gets dry, and is probably due to the overcharged condition of the cells and vessels of the leaf, owing to evaporation having been prevented by the saturated condition of the atmosphere.

The sap will in this case be comparatively poor in soluble constituents, therefore different after-treatment of the leaf will be required, than in cases where the leaf is plucked in fine dry weather, and the sap more concentrated, otherwise the produce must vary in quality and strength.

Leaf gathered on a wet day should, I think, be rather over withered to concentrate the weak sap, and should be subjected to a somewhat hard and prolonged rolling to break all the cells and distribute the juices over the whole of the leaf; while in the case of leaf gathered in fine weather, the sap being more concentrated, less withering is required and rather less rolling.

In estates containing large areas of bushes of various jâts, where the leaf brought in for manufacture varies almost daily in character, certain modifications are also necessary to produce tea of even quality.

When the leaf is from high class bushes, it withers more easily than leaf from poor hybrid or China bushes owing to the softer texture of the epidermis of the leaf, and consequent permeability to moisture, hence such leaf could be spread more thickly.

Properly withered leaf usually gives out a fresh pleasant aroma, quite different to the ordinary vegetable smell of badly withered leaf ; this fact was noticed by the Chinese manufacturers, who shook and patted the green leaf until this particular smell was developed, when it was immediately rolled. I have not noticed this aroma in leaf that has been plucked very wet, and withered under unfavourable conditions, and even under the most favourable circumstances it soon disappears if the leaf is allowed to remain for some time unrolled. The object of the Chinese in patting and tossing the leaves is evidently to hasten the withering process by breaking the smooth gummy surface of the leaves, and so favouring more rapid evaporation. The general impression among planters is, however, that the leaf is better untouched during the withering process, as bruising only discolours it especially when of good jât, and would tend to set up chemical changes, which should not be commenced until after the rolling.

The length of time that leaf should be withering can only be regulated by using artificial means of drying. From noting the different periods taken on different gardens, it is evident that practically as good a tea can be manufactured from rapidly, as from rather slowly, withered leaf, provided the temperature employed to effect the former has not been too high ; no appreciable chemical difference in the constituents of the leaf in either case could be discovered, but it is probable that a partial development of the essential oil takes place, which would account for the aroma noticed above.

Evaporation of the moisture of the leaf would take place most rapidly when the underside of the leaf is turned uppermost owing to the stomata or breathing spaces being on that side, and from which the moisture could more easily escape, but as it would be impossible to place the individual leaves in this position, turning once or twice during the process would tend to equalize the withering of all the leaves, and also to hasten it.

The reason leaf takes so long to wither in wet weather is, that owing to the saturated condition of the atmosphere, little or no evaporation from the leaf surface can take place.

During the rains in Assam, the atmosphere is very frequently within two or three degrees of saturation, although the temperature is high. As this almost saturated air passes over the wet and cold leaf, its temperature is lowered, and instead of taking up moisture, it tends to deposit it. At such times withering naturally is impossible, and large quantities of good leaf are ruined, becoming black and half rotten, unless some means are adopted to dry it artificially, as the employment of withering lofts or machines.

As mentioned before, artificial withering consists essentially in the passing of warm dry air over the leaf, the air in this state having the greatest capacity for absorbing extraneous moisture. It is heated either by the waste heat from the engine and drying machinery furnaces, or by special furnaces built for the purpose.

In withering machines, leaf can be withered far more quickly than in lofts owing to the possibility of thoroughly drying the air that passes over the leaf. This dry air, if heated only to 80° or 90° F. will take up a large amount of moisture in passing slowly over the fresh leaf; and as the above temperature is not more than that of the surrounding atmosphere during the flushing season, the leaf is exposed to a minimum risk of any unfavourable change in the process. Less dry air also has to be passed over the leaf to produce the same results, and a considerable saving of power required to drive a fan is effected. The length to which air can be drawn over fresh leaf before it becomes almost saturated with moisture varies from 30′ to 35′, depending on its dryness in the first instance, and whether the leaf is covered with, or free from, extraneous moisture; but 30′ is usually the utmost from which satisfactory withering results can be obtained. The following figures obtained experimentally will show the degree of saturation of the atmosphere at different points in an ordinary withering machine (Turton's):—

	Temp. C. F.	Degree from Saturation. C. F.
Ordinary atmosphere before passing through the furnace ...	30°=86°	4·5°=8·1°
Ditto in Tea House... ...	39°=102·2°	9.5°=17·1°
Ditto in hot air chamber ...	41°=105.8°	14°=25·2°
Ditto after passing over 24′ of fresh leaf.	34°=93·2°	3°=5·4°

It will thus be seen that, although the temperature of the air after passing over the leaf has only been reduced to about 8° F. of the temperature of the ordinary atmosphere, the point of saturation has reached 5·4° F., which would prevent any further evaporation of moisture from the leaf, and withering would practically cease.

The temperature of 105.8° F. employed in the above instance is too high to produce satisfactory results unless the leaf is continually turned, as it was found to completely dry, and give a brown colour to the leaf placed nearest to the furnace end in a very short space of time. A high temperature might be employed for a few minutes at the commencement of the withering, if the leaf was very wet with extraneous moisture, but it should be lowered to about 90° F. as soon as this moisture had been removed, and continued at the same until the operation is concluded. It is almost an impossibility to obtain a satisfactory wither from leaf that has been allowed to turn red, either through being pressed in the baskets, or from being carried in bulk for long distances. Such leaf always becomes more or less black on withering, and portions of the leaves become crisp and brittle, which are broken in the rolling process. It also rarely develops the aroma common to well-withered sound leaf, and must result in the production of a poorer class of tea. There is apparently no remedy when once the damage is done, so that prevention must be adopted as far as possible, by not allowing the leaf to be pressed down, or retained in the baskets for too long a period, and by hastening the means of transit, when the leaf has to be carried in bulk from out-gardens to a central factory.

Withering in the sun is not often practised on a large scale, except when a succession of damp dull days has so prevented withering in ordinary houses, that advantage has to be taken of every slight improvement in the weather. The general opinion of Indian planters is, that leaf withered in the sun does not produce so fine a tea as that withered in the shade, and this no doubt partly accounts for the system having been largely discontinued since the earlier days of manufacture in Cachar and Assam. In Java, however, it is said that the sun is necessary to bring out the flavour.

ROLLING.

In China up to the present day, and in India to a comparatively few years ago, this was entirely performed by hand, the leaves being rolled with a circular motion and slight pressure on bamboo trays or tables, until a certain amount of juice was expressed, and the leaves reduced to a mashy state.

After some time certain rolling machines, whose action was somewhat similar to the movement of the hands of the coolies, were introduced, resulting in a great saving of labour, by preparing the leaf for finishing with the hands. Later on improved machines were invented, which were capable of completely finishing the rolling process, without it being necessary to finally work the rolled leaf with the hand; but several of them were heavy and cumbersome, and required much power to drive them. At the present time, the latest kinds of rollers employed are exceedingly satisfactory, doing their work cleanly, thoroughly, and quickly. That known as the "Rapid" is the best of all, though some planters state that the older cross-action machines give a better twist to the leaf. The best kinds have a granite or cement top to the lower table, which greatly assists in keeping down the temperature of the leaf during the rolling process; they are also easily washed and cleaned after work, and being free from nails or any iron, the leaf is not likely to become discoloured. This discolouration is due to the formation of tannate of iron by the action of the tannic acid in the expressed juice, and specially occurs in old wooden rolling tables, where the heads of the nails, or other ironwork, come in contact with the leaf.

The "Rapid" roller is also fitted with a self-acting apparatus to regulate the pressure on the leaf, which latter can also be increased or diminished at will by a simple screw adjustment, and the leaf hard or lightly rolled according to its requirements. Another recent improvement is the introduction of a perforated top, which is said to greatly assist in reducing the heat from friction, by allowing the escape of any heated air.

The main object of rolling is of course the breaking up of the cellular matter of the leaf in order to liberate the juices, so that when the tea is treated with water they may dissolve freely, and to give a twist or roll to the leaf.

Certain chemical changes take place during this process, being more pronounced when the temperature of the leaves is allowed to rise, and the rolling is maintained for a long period.

When pressure is applied in the roller to the leaves, if the latter are properly withered, the intercellular matter alone is broken to any extent, the tougher epidermis merely being bruised and twisted, as the leaves assume their proper rolled form.

With the breaking of the cells, the juice or sap, which contains certain chemical constituents easily acted upon and changed by the air, is partially expressed, and spread over the external surface of the leaves. Here it is exposed directly to the action of the atmosphere, often at a comparatively high temperature, generated from the friction in the rolling machine, and the tannic and other organic acids undergo a certain change.

Oxygen gas is absorbed from the atmosphere, the tannin thereby assuming a dark colour, and being partly changed to an insoluble form, while part also apparently combines with the albuminoid matter of the leaf, forming an insoluble leather-like substance ; this gives to the leaves a tough and leathery character, which is largely increased during the subsequent oxidation process.

There is also a partial development of the essential oil of tea, but its presence can rarely be detected by the smell, as it is disguised by a peculiar, but not unpleasant, vegetable odour, arising from a slight decomposition of the organic matter.

The changes taking place at this stage should be minimised, as much as possible, by keeping the leaf cool. For this purpose, the rolling machines should be situated in the coolest part of the house, well removed from the engine or drying machinery furnaces, but conveniently placed to receive the freshly-withered leaf.

As regards the time of rolling and the pressure to be given, this would be regulated by the kind of leaf, and the extent to which it is withered.

Tender, large-celled leaves of the indigenous or best hybrid jâts would require very careful rolling, the pressure being fairly light throughout, while those of a poorer class would need a greater pressure, as also over-withered leaf.

Whatever class of leaf however has to be rolled, the machine should never be too full, and the pressure should be light at first, and increasing gradually until the end of the process ; for, if a heavy pressure is applied immediately, the larger leaves do not get a fine twist, but are squeezed and flattened, which gives to the finished tea an unsightly appearance, besides causing a higher percentage of broken leaf, as the flattened leaf, when dry, is very easily friable.

The average time allowed for the first rolling of the leaf is about 20 minutes, after which it is removed from the roller and passed through a revolving sieve of bamboo, cane, or wire mesh. By this means the greater part of the coarser leaves and stalks are separated from the fine, and the former can then be immediately re-rolled for another 10 minutes, with slightly increased pressure to improve their twist, and squeeze a little more sap over their outer surface, In some factories the leaf is rolled two or three times during the oxidising process, but with fine leaf containing much tip, this is unnecessary, and sometimes even harmful, as the leaf is more liable to become discoloured by the exuded juices, and by the extra handling and bruising it receives. For the coarser leaves it is an advantage, since they do not retain their twist as well as the younger leaves, and it is almost impossible to over-roll them, as the more evenly sap is expressed, the better will be the colour obtained during the oxidation.

The fine leaf should, however, always be rolled again lightly when the desired colour has been *nearly* obtained, so as to retwist any opened leaves: it will be found also, that if the leaf is not too dry or over oxidised, the coppery colour will brighten up considerably during this final rolling. The leaf should then be passed through the revolving sieve again to break up any lumps, and immediately placed in a drying machine at a temperature of about 280°F. until it is half dry, when it can be allowed to cool, and remain untouched for some time without harm.

Should the firing process be delayed for even a few minutes after the leaf has attained its proper colour, the latter will rapidly become darkened, and the liquor and infused leaf will not be so satisfactory.

OXIDATION PROCESS.

The term "Fermentation" has been usually applied to this process, but "Oxidation" more correctly describes the changes in the leaf that take place in the comparatively short time allowed. If however the leaf was allowed to lie in heaps for many hours, the temperature would rapidly rise to between 90° and 100° F. and a kind of fermentation would set in, accompanied by decomposition.

This process is perhaps the most important in the whole manufacture, as both the good quality and appearance of the tea depends largely on the process being properly carried out, and for this purpose certain conditions are necessary:—

A separate room is required, which must be well removed from the heat of the firing machines, and protected from the sun, by a double roof, as it is impossible to oxidise the leaf properly, and to obtain a good colour if the room is too hot. It should be conveniently situated to receive the leaf from the rollers, and pass it on to the drying machines. The floor should be of cement, sloping to a drain either in the centre or at the outside, to facilitate the washing and cleaning of the room when the day's work is over. It has also the advantage of absorbing a large amount of the heat generated by oxidation from the layers of leaf lying upon it, and thus assists in keeping the temperature down.

In the early part of the season, when the weather is comparatively cool, and it is difficult to obtain a good colour on the leaf, the leaf will oxidise more readily on trays of canvas or jute cloth than on the floor; but, if the leaf is placed in thicker heaps, and not turned too often, the temperature will rise sufficiently to assist in the colouring.

As the season advances, and the temperature of the atmosphere rises, the leaf must be placed in layers not exceeding 4″ to 5″ in thickness, and turned every half hour to prevent the temperature rising too high. About 85° F. is apparently the most suitable temperature for the heaps to attain, but it is very difficult to keep it as low as this, when the surrounding atmosphere is over 90° F. Covering with damp cloths and keeping them moist with cold water assists in keeping it down, especially as on hot dry days evaporation takes place very rapidly, and by the absorption of heat, also reduces the temperature of the leaf.

When the leaf is first brought from the rollers, it is of a bright green colour (if properly withered), but after lying about half an hour, under favourable conditions of temperature and moisture, it begins gradually to assume a reddish tint, especially near the spots where the leaves and stems are fractured. This change continues until the younger leaves and stems are a bright coppery colour, while the older and less perfectly-rolled leaves are partly reddish and partly green: the leaf must now be re-rolled and fired, as it would be impossible to wait for the complete disappearance of the green colour, or the finer leaves would be spoiled. A more even colour is obtained by sorting the leaf as mentioned under rolling, and placing the different grades in separate heaps to oxidise, whereby the older leaf can remain for a longer period without injury to the other.

Should the leaf have been over-withered, and the sap reduced to too great a degree of concentration, the colour obtained in the oxidation will be dull and dark, instead of bright coppery; this can be partially remedied by moistening the leaf with clean water, either during the first rolling, or when the leaf is put to oxidise, by which means the concentrated sap is better diffused over the leaves.

In all cases the leaf and atmosphere of the oxidising room must be kept damp by sprinkling with cold water, and it is advisable to protect the leaf from droughts by means of wet cloths placed over the heaps; if this is not done, the surface of the heaps will assume a blackened appearance, owing to the leaf drying up, and the too rapid oxidation of the tannin and colouring matter.

A perfectly moist draught of air would probably not be of any harm, and would possibly hasten the oxidation and change, but it would be necessary to frequently moisten the surface of the heaps during the process.

The following experiments were made in Assam to determine whether the changes, which take place during the process, were due to the presence of either an organised or soluble ferment, or merely to oxidation :—

1st.—Freshly rolled leaf was placed under a receiver, and the air exhausted as completely as possible. Little or no change took place, and the leaf at the end of 24 hours was still a dull green colour, with a little brown colour on the stems. Admission of air or oxygen at this period had no effect on the colour, probably owing to the comparatively dry condition of the leaf.

2nd.—In this experiment the air was exhausted as before, and pure dry oxygen gas admitted; in half an hour the leaf had attained a bright coppery colour, and in two hours the whole of the leaf was a uniform dark red, and had gone beyond the stage required for ordinary manufacture. Duplicate experiments were made of the above with similar results, and in each case a sample of the same leaf was treated in the usual manner for comparison, with the experimental leaf, the flavour of the teas treated with oxygen gas did not differ from the ordinary teas, but the infusion had a brighter appearance.

3rd.—The rolled leaf was treated in vacuo with pure carbonic acid, which is an inert gas, with the result that at the end of 5½ hours it was still a dirty green colour, while a sample treated in the usual manner attained the required colour and condition in 3 hours.

4th.—The leaf was exposed to a limited supply of air, and even after 20 hours was still of a greenish colour, and the tea manufactured from it was very pungent, showing that little of the astringent properties had been destroyed.

5th.—The rolled leaf was treated with dry steam at a high temperature for a few minutes, and was then treated as usual, when it attained a good bright colour.

6th.—The rolled leaf was treated with air and oxygen gas, which gave a bright colour, the liquor was flavoury, but not very pungent, and infusion bright.

All the above experiments tend to show that the change in the leaf in the so-called "fermentation" is due to oxidation. Microscopic examination has failed to show any organism; and the fact that the change will take place in an hour or less from the breaking of the cells is, I think, conclusive evidence that it cannot be due to the development of living organisms. Experiments on a larger scale show, that a certain moist condition of the atmosphere and of the leaf itself is necessary to obtain the desired colour, and also that the best results as regards flavour, pungency, &c., are obtained when the temperature of the leaf does not rise spontaneously above 84°—86° Fahrenheit. To obtain these conditions it was found necessary that the house used for this purpose should retain as uniform a temperature as possible, also that no fixed rule could be laid down for the thickness to which the leaf should be placed, as the conditions on each garden are so variable. If the leaf is placed on a cement floor where the heat is partially absorbed as it is developed, it can be thicker than when placed on boards or cloth raised above the floor; and as a general rule, the cooler the day the thicker the leaf can be placed to obtain the necessary colour in an uniform time. When the leaf is over-withered and therefore too dry, it either requires a harder rolling to express more of the sap, which takes the colour, or it is advisable to moisten the leaf slightly with a fine spray of water, besides keeping it covered with wet cloths.

The chemical changes that take place during the process are numerous, one of the most important being an increase in the amount of essential oil, to which the flavour of tea is so largely due. A certain amount of volatile fatty acids are also developed from the splitting up of a portion of the albuminoid matter in the leaf and the sap developes an acid reaction. Some of these on isolation have a sweet nutty flavour and aroma, to which the peculiar smell of properly oxidised leaf is due. If the process is prolonged for many hours, the acidity of the sap rapidly increases, and the leaf becomes sour and rancid, acids similar to those present in rancid butter being developed. These can be got rid of to a certain extent during the firing processes, by exposing the leaf to a high temperature for a lengthened period, but only at the expense of the volatile oil which is dissipated with them.

These acids are not present in the green leaf at all, and usually only traces of them are found in the finished tea, being carried away by the steam during the drying process.

A slight loss of soluble matter takes place during this stage, and the astringency due to the tannin is greatly reduced. The latter results partly from the tannin being oxidised into an insoluble brown substance known as "Phlobaphene," and partly from its combination with some of the albuminoid matter, which gives the leaves a tough leathery and elastic character, easily noticeable on handling. Part of the tannin is also converted into glucose and gallic acid, the former of which tends to give a sweetish flavour to the tea; the latter is less astringent than tannin, and has not the power of combining with albuminoid matters.

Another cause of the smaller amount of soluble matter in the oxidised leaf is the coagulation of the albuminoid matter by the acidity developed during the oxidation, the greater part of the nitrogenous matter being in the form of an alkali albumen called "Legumin" which has properties very similar to the casein in milk, and is precipitated like the latter on the acidification of its solution.

It is unfortunate that the above change should take place, as Legumin is a valuable food material, giving to the plants of the leguminous order their highly nutritious character. In tea, it is of course wasted, as it remains in the leaves after the treatment with water; it could be largely extracted by the addition of a small quantity of alkali as carbonate of soda to the water, but only to the detriment of the flavour.

Carbonate of soda is occasionally used for darkening the colour of tea, and obtaining a strong looking liquor in the cup; but the practice is not to be recommended. It assists in the solution, not only of the legumin, but also of the tasteless phlobaphenes, and other constituents, whose presence in the liquor is not desirable.

FIRING OR DRYING.

This process generally takes place in two or three stages, the leaf being passed through one or more machines until the last trace of moisture has been expelled, and the tea has obtained a crisp character and touch. Several kinds of machines are in use, in most cases heated air being drawn over the leaf, either by means of a revolving fan, or by long chimneys which promote draught, while in one or two instances the heated products of combustion of wood, coal, or coke are blown over the tea, complete combustion of the gases being attained by special arrangement in the furnace, in which the partially burned gases are filtered through red-hot quicklime, or other porous material before passing over the leaf. The temperatures employed in different machines and on different estates vary exceedingly, and I think this is one of the chief factors which cause such variations in value and price of the tea produced. The temperature cannot always be regulated and kept at one fixed point, nor would it always be required; but I have often seen the temperature of a single machine vary over 30° or 40°F. within a few minutes, which certainly cannot turn out tea of a uniform character. Such variation is most noticeable in machines having a powerful draught, or air current, and which require the most careful stoking, and closest attention to obtain a uniform temperature.

Numerous causes are continually occurring to produce sudden variations in temperature, such as the opening of doors and trays in the machines, filling in large quantities of cold wet leaf, irregular stoking, by which the fire is allowed to get too low before adding fresh fuel, and then adding large quantities of the latter, whether wood or coal; and finally the employment of wet and sodden wood for firing. The latter fault is very general, and causes a great waste of fuel, as much of the heat generated by the combustion of a portion is employed in driving off the excessive moisture from the other, before the latter will produce useful heat for the drying of the tea.

This can only be remedied by collecting the wood for fuel during the dry season, and storing it under cover, where it is protected from the rain; or if stacked in the open, the logs should be built up to slope slightly outwards, and arranged in such a manner that a portion of the stack could be removed at a time from top to bottom without disturbing the whole upper surface. The top of the stack should also slope considerably to throw off the rain, and prevent it soaking through the whole heap.

If built in a proper manner, it will be found that, with the exception of a few layers at the top, the remainder of the wood will keep perfectly dry, as well as if kept under a shed, and when burned, will give out its full heat value for drying the tea.

The importance of immediately checking the oxidation process when it has arrived at its proper stage is well known to every planter, and this can only be effected by suddenly exposing the wet leaf to the action of *dry* air at a temperature considerably above the boiling point of water. If therefore wet fuel is employed at this stage, the air, although heated, will be almost saturated with moisture from the wood, and incapable of rapidly removing moisture from the leaf, which will thus proceed beyond the proper stage of oxidation before it is checked.

But even at any stage of the firing, it is necessary to have the heated air as drv as possible, otherwise the leaf will become partially steamed and stewed before it is dried, which will not improve its quality, besides limiting the possible outturn from the machines during the day, and necessitating the continuance of the work far into the night.

Given plenty of dry fuel, there should be no difficulty in maintaining an equable temperature in any machine, if the stoking is properly carried out, and at the right time. In the *first* instance, fuel should not be applied at the same instant that fresh wet leaf is being placed on the trays, otherwise the temperature of the air will be lowered to too great a degree, and it will be some minutes before it can again rise to its proper height. *Secondly*, fuel must be added in small quantities at a time and frequently, so that the fire may never fall too low, but always have some fresh material burning; it will be found that by adopting such a system a great saving of fuel is effected, and a more uniform character given to the tea by being dried at an even temperature.

The main object to be aimed at in firing is, of course, to remove all the moisture, without driving off and losing any of the constituents which add to the flavour and consequent value of the tea. Under the system of high firing so frequently adopted, a considerable loss of the chief flavouring constituent, an essential oil, results. This loss can be prevented to a considerable extent by carefully regulating the temperature employed at the different stages of the process.

The loss takes place almost entirely during the final firing, when the leaf has little moisture left in it, and is due to the high temperature employed, and the rapid escape of moisture as steam, which carries the oil away mechanically.

Analyses show that there is a considerable increase in the amount of essential oil during the first firing, which is probably due, partly to the bursting of the inner cells of the leaf by the rapid expansion of the water and steam contained in them and its consequent liberation, and partly to certain chemical changes in the constituents of the leaf; but this firing, in which only about 40 to 50 °/₀ of the moisture is expelled, is not sufficiently prolonged to cause a loss of the oil.

Although, as a rule, the temperature employed for the first firing averages about 27°F., the actual temperature of the wet leaf is far below this, as evaporation proceeds so rapidly that it cannot rise to the temperature of the heated air; but during the second firing when the leaf is partly dried, although the temperature employed in the machine is not so high as in the first instance, the leaf itself attains within a few degrees the temperature of the machine, since evaporation is not so great, and it is the prolonged high temperature at this stage which causes the loss of oil. Consequently, during the final firing when the last of the moisture is being expelled, the temperature should be somewhat below that of boiling water, or from 180°F. to 200°F., and the draught employed should not be very great, so that the moisture will not be driven off too rapidly.

A low temperature for this final firing has been employed on many estates for some time, and it has almost invariably been found to produce a flavoury and valuable tea, so that the analyses merely confirm and explain the benefit of such a process.

The most suitable machines to use for the different stages of firing are, *first,* one having a fan and travelling webs by which the leaf is turned several times during the process, and no portion remains for a sufficient time in contact with the heated iron to become charred or burned; also the dry heated current of air passing rapidly over the leaf removes the excess of moisture, and fixes the constituents of the leaf, preventing further change; and, *secondly,* for the final firing, a machine through which only a slight current of air passes (as produced by a lengthened chimney), in which the leaf can be constantly watched, and turned when necessary by hand.

In both cases, large-sized machines are the best, as the temperature can be more easily regulated, and there is less liability to excessive variation when fresh leaf or fuel is added.

The machine known as the "Victoria" appears to be well suited for the first firing as it possesses all the qualifications for quickly removing 50 or 60 % of the water from the wet leaf, which is sufficient to prevent the leaf changing colour until finally fired, if the latter process is not too long delayed. The action being continuous gives the machine an advantage over other machines in which ordinary trays are employed, as there is less liability of an accumulation of oxidised leaf occurring from want of space in the machines.

Other machines, such as the Down Draught Siroccos, do good work however, but great care is necessary in spreading the leaf evenly on the trays, otherwise, while one portion is still almost as wet as when placed in the machine, another portion may be nearly dry, and, if the process is continued a little too long, becomes almost burned from the high temperature (256°—260°F.) employed, before the rest is half dry.

It appears that, with the enormously rapid draught in these machines, the heated air is not properly diffused over the whole surface of the trays, but this could be remedied by placing a perforated iron plate above the uppermost tray, the holes being made largest where it has been found that least air penetrates the trays.

It is, I think, doubtful whether it is advantageous to employ such extremely rapid currents of air in these machines, especially in cases where the ordinary trays are employed. More satisfactory results would probably be obtained by using a less rapid current, but of *dry* air, as there would then be less tendency to any volatile constituents being removed: the mere passing of air almost saturated with moisture through a limited length of heated flues does not dry it, but only increases its moisture-carrying powers to a certain extent by raising its temperature, and this property is again considerably reduced as the air comes in contact with the cold wet leaf.

The drier the air is at a low temperature, the greater will be its power of absorbing external moisture, when heated to a temperature above that of boiling water, and consequently a far less volume of such air will be required to remove an equivalent amount of moisture from the leaf. A considerable saving of fuel would also be effected in heating the smaller volume of air.

For the completion of drying, the most suitable machine is the T. Sirocco, having the openings for the trays at the side, and not at both ends, as the leaf is then under better control, it being possible to examine any one of the trays, without having to remove the others.

The trays in these machines are generally placed three or four deep, which, as the air passes upwards from one to another, is quite sufficient, otherwise the leaf in the upper trays would be liable to undergo a certain amount of stewing from the steam arising from the lower ones.

When properly fired, the tea has an excellent aroma as it is taken from the machine, but to obtain this the temperature employed must not be too great, nor the operation hurried, otherwise the aroma will not be properly developed, and the external portion of the leaves will become hard and crisp, before the interior is completely dry, and this residual moisture, unless removed in the final firing before packing, will render the tea very liable to undergo further change after it is packed. It will be remembered that in the oxidation process, among other changes which take place in the constituents of the leaf, a certain amount of volatile fatty *acids* are developed, which give to the leaf a very acid reaction. When firing is properly carried out, this acidity completely disappears, but not if a small quantity of moisture is left in the leaf. It is possible in some instances that this acidity, which would be further developed during a long voyage, has been the cause of the lead lining of boxes being partially damaged, and the tea obtaining a cheesy flavour. This is, of course, mere conjecture, as no reliable experiments have been made on the subject; but, as the acids developed in the tea are, during oxidation, the same as those occurring in rancid butter and cheese, it is not unlikely that the pronounced cheesy flavour in damaged chests is due to them. On the other hand, the cause of the lead lining being destroyed is generally attributed to the action of the wood forming the boxes. This is also possible, and in fact most probable, if the boxes have been made of unseasoned wood, as the sap is very apt to undergo certain fermentative changes, with the development of certain acids, chiefly Acetic Acid, which readily dissolves any lead with which it comes in contact.

It will be always advisable however, to destroy the acidity of the leaf by completely removing all the moisture it contains.

Tea that feels perfectly dry to the touch may contain as much as 10°/ₒ to 15°/ₒ of moisture, and it is necessary to heat it at a temperature, closely approaching or equal to boiling water, 212°F. for a considerable period before this moisture will be completely removed.

In my own experiments in Assam, where the atmosphere during the rains is almost continually saturated with moisture, to remove all moisture from oxidised leaf, the latter required heating in an oven at a temperature of 212°F. for over two hours before the last trace was driven off, the last one or two per cent. being most difficult to remove.

Under the ordinary firing process in a "Victoria," working at a temperature of from 260° to 280°F., 50 per cent. of the moisture can be removed from the wet oxidised leaf in about 10 minutes; the remainder, *i. e.*, sufficient to make the tea feel dry, can be removed by firing in a Sirocco at a temperature of about 220°F. for 20 minutes. But by this system a certain amount of the essential oil is lost, which can only be remedied by finishing the drying at a lower temperature, or about 180°—200°F., and taking care that not more than 50°/₀ of the moisture is removed in the first firing.

The use of a lower temperature as recommended will necessitate the final firing process being more prolonged, unless some arrangement is made for passing drier air than ordinary over the leaf. Additional firing machinery would therefore be required in certain instances to prevent an accumulation of half-dried leaf between the two processes, also to enable the drying of all the leaf in a reasonable time.

There is a large amount of night work on many estates during the greater part of the manufacturing season, which is generally owing to a lack of machinery for rolling or drying purposes, or to there being insufficient withering accommodation. It is at this time that the tea is most likely to be spoiled, either by over or under firing, unless continued supervision is given, which is not always possible.

SORTING OR SIFTING.—This is now either done by means of revolving or reciprocating sieves of varying mesh, worked by steam, or by the older method of hand-sifting. The latter has certain advantages over the former, as the kind and extent of sifting can be better regulated, but it necessitates the employment of a number of hands, which could be otherwise utilized. Whatever method is adopted, there is a large amount of dust produced, arising from minute particles of broken leaf, and the fluffy down or minute hairs from the back of the leaves; and if the operation is carried out in a part of the tea-house near where the machinery is placed, considerable damage is likely to occur from heating of the numerous bearings, unless adequately protected from the dust.

The operation should, therefore, be performed in a room entirely separated from any revolving machinery, but conveniently placed near the final firing machine, which is usually of the "T" Sirocco type.

It is at this stage of the manufacture that all red leaves must be removed from the tea, also flat leaves and long stalks from the finer kinds, as an even appearance of the different grades is of importance since it affects the value of the tea. Experience alone can decide what sizes of sieves to use, as it would probably vary with the jât of leaf, large indigenous leaves requiring a different mesh to the small China varieties; also with the demand for any particular grades in the market.

As the dust is of comparatively little value, the less there is produced the better; its production could be minimised by good withering, careful rolling to prevent flat leaf, and by not over-drying before breaking and sifting, as this will reduce the brittleness of the tea.

RE-FIRING AND PACKING.—The term "Re-firing" is given to the final process of drying the prepared leaf, prior to its being packed in boxes for shipment. It is done after the tea has been sorted, and when it has been lying in heaps for from 12 to 18 hours, during which period it has absorbed a considerable amount of moisture from the atmosphere, and almost completely lost its crispness of touch and brisk flavour. Drying machines having only a slight natural draught are the best for final firing, as there is no rapid current of air to drive off any essential oil which may be developed, and the aroma will be retained. The temperature employed in the firing or drying machines varies on different estates, but one ranging from 212°F. to 220°F. appears to be the most suitable for obtaining briskness, with good flavour and aroma: a higher one might be employed without risk, if the process is not too prolonged, especially in cases where the tea has a slight sourness, the result of over oxidation, as the high temperature would help to drive off any remaining volatile acid to which the sourness is partially due.

Tea, or any other organic substance, has always a tendency to absorb moisture from the atmosphere more readily, when quickly, than when slowly dried, and hence will sooner become mouldy or undergo decomposition if exposed to the air.

When sufficiently fired the tea should be allowed to cool down to a temperature above that of the surrounding atmosphere, or until it is distinctly warm to the hand. This cooling should take place in the driest portion of the Factory, and under dry cloths, which would prevent the absorption of moisture from the atmosphere; it should then be immediately packed in the usual air-tight, lead-lined boxes.

The object of packing tea warm is to prevent, as far as possible, the absorption of moisture from the atmosphere, which might tend to promote further undesirable change in the tea during a long voyage. If the perfectly dried tea was allowed to sink to a temperature of the surrounding air, it could not fail to absorb and condense a large quantity of the moisture, which so generally almost saturates the atmosphere of the Tea districts during the manufacturing season.

Tea, on the other hand, should not be packed *hot*, although it would insure the absence of moisture at the moment of packing, for, if it is, the air in the box will be heated and expanded to such a degree when the lead is soldered down, that on cooling a partial vacuum would be formed, and this would cause an inward passage of air through the slightest defect in the lead. Should there also be any remaining moisture in the tea (not driven out during the firing), which is quite possible, as tea, although perfectly dry to the touch, may still contain a considerable percentage of water, this moisture would condense on the inner surface of the lead; and, if containing traces of any of the volatile acids generated in tea during the oxidation process, the slightly acid liquid would, in time, cause the corrosion of the lead, and possibly, directly or indirectly, produce the deleterious effect known as "cheesiness," which is occasionally found in tea on its arrival in England.

In some papers relating to the corrosion of the lead lining of tea chests by George Watt, Esq., M.B., C.M., F.L.S., and P. Playfair, Esq., the former holds the opinion that the corrosion is produced by the tea itself, from the effects of a certain acetous fermentation arising from imperfect manufacture or the humidity of the atmosphere, and not from the action of the wood forming the boxes; while the latter holds a directly opposite opinion, and is supported by Dr. Voelcker, who examined several samples of wood, lead, and tea taken from chests in which the tea had acquired the peculiar cheesy-like smell. In these examinations it was found that the corrosion was confined almost entirely to the lead taken from the tops of the chests, and on the surface nearest the wood, that near the tea remaining bright and sound; it was also ascertained that the supply of box lids had run short at the Factory where the tea was manufactured, and green wood had to be employed to make up the deficiency. On distillation of some of these woods with water, and extracting the distillate with ether, oily and resinous matters in appreciable quantities were obtained, having an intensely disagreeable smell, similar to a mixture of rancid butter and rotten cheese, but which passed off rapidly on exposure to the air.

These facts all tend to point out that the wood was the cause of the corrosion, especially as it is well-known that almost all green wood will generate, under favourable conditions of temperature and moisture, certain organic acids which will act upon lead.

But, on the other hand, Dr. Watts, who experimented with pieces of lead placed between slabs of seasoned and unseasoned wood, damping and leaving them in a confined atmosphere to produce the effects of the hold of a ship, found that none of the woods caused any corrosion of the lead, although in many instances the unseasoned wood became completely rotten, while in others a fungoid growth united the lead so firmly to the wood, that the slabs could with difficulty be torn apart. On distillation of *fresh* samples of wood also, he found none having the peculiar odour described by Dr. Voelcker, and remarks from this fact that the different woods which yielded similar or identical offensively smelling distillates, might possibly have absorbed that odour from a common source, the more so since exactly the same odour was found in the tea; and he queries whether the tea absorbed its offensive odour from the wood, or imparted that formed to the wood?

He accounts for the inner surface of the lead next the tea being bright and clear, by the volatile acids arising from the acetification of tea forcing their way out through perforations made by their own action, or already existing in the lead, and accumulating between the wood and the lead, there causing corrosion and the formation of carbonates and other salts of the metal. This theory is possibly correct, but it is also possible that the corrosion and deposition of salts might take place on the inner surface of the lead as well, only in this case it would be removed as formed, and a bright surface maintained by the friction of the tea produced from the vibrations of the vessel; while on the outer surface no such friction would exist, as the contact of the lead and wood is rigid.

There is no doubt, however, that both the tea and the wood might cause the "cheesiness," as they both are liable to undergo a kind of fermentation, resulting in the formation of certain volatile and non-volatile organic acids, similar, if not identical, and having a corrosive action on lead. The remedy however, I think, rests partly with the planter, and partly with the supplier of boxes or box wood; not so much in the rejection of certain kinds of wood for box making, though some woods may be more liable to acetification than others, but in only employing perfectly-seasoned wood for the purpose. The proper seasoning of wood, or the removal or destruction of all easily fermentable matter, would not take long in a climate like Assam, where if cut into planks and properly exposed to the atmosphere, the wood would be subjected to heavy rain and hot sun alternately, for several months of the years, and then to a prolonged period of dry, warm weather. Under these circumstances the acid products of any fermentation would be washed out, and the wood rendered harmless.

The chests, however, should be protected as much as possible from rain during shipment, for, if the wood is damp when the chests are stored in a ship's hold, the moisture would dissolve some of the carbonic acid of the confined and heated air, and would then have a considerable solvent effect on the lead with which it came in contact.

On the planter's part the remedy lies chiefly in the perfect drying of the tea, which would render any further fermentative changes taking place impossible. In the oxidation process the acidity which develops should not be too pronounced, but should be checked at the proper period by exposing the damp leaf to a high temperature as described under the head of "Firing" or "Drying."

In most cases also, especially when the tea is tightly rolled, the final firing should be as prolonged as possible, care being taken that only a low temperature is employed, for it is very difficult to expel the last traces of moisture: it is also generally believed that exposing the leaf to a prolonged gentle heat develops more fully the peculiar aroma of good tea.

INSECT BLIGHTS.

CHAPTER VIII.

The insect pests which attack the tea plant are now very numerous and of varied description. Some of them as yet have fortunately not caused any great damage, but unless they are now checked, it is more than probable that many of the insects and blights, which are at present practically harmless, may develop to an extent likely to cause serious loss in the future. Others, such as the Mosquito Blight (*Helopeltis theiovora*), Green Fly (*Chlorita flavesceus*), Fabs., and Red Spider (*Tetranychus bioculatus*) Mason, have now for several years caused great loss to planters, owing to their having spread throughout most of the tea districts, not only unchecked, but favoured by the large areas of new tea land opened out in recent years.

Several causes have been at work in assisting the development of blights on tea during past years, and they are still continuing to a great extent.

Experience in all countries has shown that when large areas are continuously cultivated with the same crop, such crops become very liable to insect and fungoid attacks, which ultimately may necessitate the discontinuance of the growth of the crop for some years, if not for good. This liability to attack may be due to several causes: it may be that the plant has become weakened from the constant abstraction from the soil of the most important mineral constituents, until one or more are too deficient to allow healthy growth Such a deficiency would not only check growth, but would also cause a change in the proportion of the organic constituents in the plant itself, and it is probable that such a change has taken place in the case of tea.

The crossing or hybridizing of different *jâts* also causes a change in the character and properties of the leaf, which appears to have been favourable to some insect blights, as, for instance, the Mosquito Blight, which originally rarely attacked the Assam indigenous bushes, preferring the hybrid or China plant, but now is attacking all classes of plants indiscriminately. It was supposed that the pungency of the indigenous bushes, due to the tannin, was the cause of their remaining unattacked, the less pungent hybrid and China leaves being more palatable to the insects ; but gradually either the pungency was lessened, or the insects got accustomed to the taste of the juices of the leaf as a food.

Imperfect cultivation, want of drainage in certain soils, planting out of stunted and weakly bushes, and numerous other causes have tended to facilitate the spread of blights throughout the tea districts.

Climate also has a great effect on their distribution, any excessive conditions of rainfall, drought, heat, or cold, being suitable for the development of one or more of the blights, and at the same time unfavourable for the growth of the plant. The prevailing direction of the winds at certain seasons of the year has also been said to affect their distribution.

Although most of the blights, with their life history, have been described, the information given is not always complete, and few planters know the changes undergone, and the period at which such changes occur. Such knowledge is very necessary in most cases to enable the planter to attempt the destruction of the blights with any prospect of success, as they must be attacked when in their most vulnerable condition. It is probable that the period of change is not exactly the same in all districts, being affected by climatic and other conditions, but careful daily examination of suspected blighted bushes, with the aid of a microscope or ordinary magnifying glass, and recording of observations would reveal the stages in the life of many of the minute insect blights, and enable the observer to apply insecticides, or adopt other means of eradication at the most suitable time.

For certain blights several remedies have already been tried, in some cases with success, but the use of insecticides is as yet very far from being general, chiefly owing to the want of an effective machine for their distribution, which would reduce the cost of application to a minimum, and enable a large area to be treated in a short space of time.

As a general rule blights commence their attacks on a comparatively small portion of a garden, so that if taken in time, it might be possible to check their further advance, without having to treat a large area.

To do this will become more difficult year by year unless some prompt remedies are soon taken, for with the extremely rapid spread of these insect blights, it will be found that the eggs are more widely distributed, and the blight will appear suddenly over larger areas than at present.

From the great increase of some of the most destructive blights during the past few years, it would appear that the insects are comparatively free from either-parasitic or other enemies: the discovery of the former class of enemies, which are almost certain to exist, though in small numbers, and the favouring of their development, may possibly prove one of the chief means of preventing the ravages of the blights. From what I have observed in Assam, there are apparently few birds which live on the insects attacking tea; but should any have been observed in other districts, they should be protected and encouraged as much as possible.

Through the kindness of Mr. E. C. Cotes of the Indian Museum, I have been furnished with a list of the insect enemies attacking tea, which is now given, together with any additional notes from personal observations:—

Coleoptera. Beetles.

Melolonthini. Cock-chafers or White Grubs.

Lachnosterna impressa, Burm.—A thickset brown beetle, with curved white fleshy grubs. This insect chiefly attacks young tea plants in a new clearance or nursery, by biting through the stem below the ground. They live in holes in the ground, which in a clean nursery can easily be seen. The only known remedy is to dig up the soil wherever the holes are observed, and collect the grubs. It occurs in all the tea districts, and has been known to do great damage, especially in clearances where the seed has been planted at stake. In clearing new forest or grass land, care should be taken that all the beetles and larvæ observed when the land is first broken up, are collected and destroyed, as a little extra care at this stage may prevent much disappointment and expense at a later period. With the aid of lamps, collecting the grubs at night when out to feed would probably prove a satisfactory method for lessening their numbers.

Chrysomelidæ.

Diapromorpha melanopus, Lacord. (known as the orange beetle).—A small yellow beetle reported as attacking tea shoots in Sibsaugor, Assam; but at present the damage done has been small.

Heterocera. Moths.

Zeuzera coffeæ, Nietner (*Cossidæ*) known as the red borer of coffee bushes in Southern India, also reported as tunneling into the stems of tea bushes in Ceylon and Cachar. The moth is a fluffy white insect, speckled with dark greenish spots. The work of the borer is generally discovered only when the plant falls over from the inside of the stem having been eaten, though small heaps of sawdust can be seen near the base of the stem if carefully looked for. The caterpillar attacking tea is from 1″ to 1½″ long, and of a dull colour, and changes to a moth within the stem. The moth escapes and the females deposit their eggs in the stems of new plants. They chiefly attack young bushes, but have been seen in plants up to 18 or 19 years of age. The full grown caterpillar can be found about December, after which it changes to a moth, which appears in March. The only thing to be done when a bush has been eaten through is to cut it off below the hole, on the chance of its sending out new shoots, and at the sametime taking care to destroy the caterpillar, which will be found in the interior.

Psychidæ. Bagworms.

Eumeta crameri, Westw.—The caterpillar of this moth builds a case almost exactly like a miniature faggot of sticks, in the middle of which it lives. It defoliates tea bushes by eating the young leaves and cutting off the stems or internodes to make its case ; fortunately it has not been found to do very widespread damage owing to its limited numbers, and it can easily be kept in check by collecting and destroying the caterpillars when seen. Care should be taken that all old cases are collected, for it is usually within these that the eggs will be found, as the female moth does not leave the case at all. As soon as hatched the young larvæ commence feeding on the juices of the leaves, and as they grow, gradually build for themselves new cases.

Eumeta sikkima, Moore.—The caterpillar of this moth builds a large rough case out of bits of leaves and sticks, and has been said to defoliate tea, but does not do much damage. Another undetermined Psychid has also been reported as defoliating tea plants in Ranchi.

Bubula sp.—The caterpillar of this little moth builds for itself a conical case from the epidermis of the leaves on which it lives. I have only seen it on a few bushes in Assam, but these it completely defoliated, being present on the bushes throughout the whole season, and preventing their flushing. The caterpillar is small and dark coloured and changes to a little dark coloured moth within its case. Hand-picking is the simplest remedy, and can easily be accomplished.

Limacodidæ.

Parasa lepida, Cramer (= *Limacodes Graciosa,* Nietner), known as the "blue-striped nettle grub" by Ceylon planters, has been reported as defoliating tea and coffee bushes in Ceylon (Nietner and Green). Others undetermined have been reported as defoliating tea bushes in Darrang, Assam.

Notodontidæ.

Stauropus alternus, Walker, or the Lobster Caterpillar, said to attack the foliage of tea and cocoa in Ceylon, also seen in Darjeeling. The caterpillar spins a cocoon between two leaves, and after the change emerges as a brownish grey moth. The damage done in India is very limited; but whenever seen, the caterpillar should be destroyed to prevent further spreading.

Arctiidæ and Liparidæ.

Fluffy moths with hair-covered defoliating caterpillars.

Dasychira thwaitesii, Moore (*Liparidæ*), reported as doing much damage by defoliating tea and sâl (*Shorea robusta*). The sâl trees throughout 200 square miles of forest in Assam are said to have been defoliated by it in 1878.

Olene mendosa, Hübn. (*Liparidæ*), reported as attacking the leaves of tea bushes in Darjeeling.

Orgyia ceylonica, Nietner (*Liparidæ*), said to attack tea bushes in Ceylon.

Other undetermined hair-covered caterpillars allied to the preceding, and thought to belong to the *Arctiidæ* are said to have attacked tea in Jorhat, Assam.

Noctues.

Agrotis suffusa, Fabr. (*Noctuidæ*).—The moth is thick bodied with thread-like antennæ, and the larvæ are smooth brown caterpillars, which do much damage by biting off young plants just above the ground, a single caterpillar often killing several plants during one night. The caterpillar changes to a chrysalis under ground, and these should be carefully collected from clearances when exposed by cultivation; the caterpillars should also be collected early every morning, and any that may have disappeared under ground for the day should be dug out from their holes, which are easily visible in clean land.

Geometres.

The moths are usually slender built creatures with large wings and comb-like antennæ. The caterpillars are long, slender, and smooth, have but few prolegs, and these set very far back: they hump up the middle of the body into a loop in progressing, and are hence called "Loopers."

Certain of these obscure looper caterpillars have been reported as defoliating tea bushes in Nowgong, Assam; but the damage done is very limited.

Microlepidoptera.

[Minute moths with very varied habits.]

Pandemis meuciana, Walker (*Cacæcia sp.* Green).—A Tortricid said to damage the leaves of the plants in Ceylon, chiefly by rolling up the leaves. The rolled leaves are easily seen and can be plucked and destroyed with the enclosed caterpillar. A similar caterpillar is also seen in Indian tea districts.

Gracilaria theiovora, Walsingham (*Plutellidæ*) reported as attacking the tea plant in Ceylon (Green). It rolls up the tea leaves, and can be destroyed in the same manner as the preceding. It is said to be preyed on by Ichneumons, small parasitic flies.

Diptera.

Agromyla Gr.? Oscinis theæ, Bigot (*Muscidæ*).—The grubs of this minute fly are said to tunnel into the leaves of tea bushes in Ceylon. They are not thought to do any appreciable damage.

Rhyncota.

Helopeltis theiovora, Moore (*Capsidæ*).—Superficially very much like a mosquito, and hence generally known as the "Mosquito Blight." In Ceylon the mosquito blight which attacks tea has been referred to as *Helopeltis antonii*, Signoret, a species which has also been reported as a formidable enemy to Cacao (Theobroma Cacao) in that island, while in Sikkim a closely allied or identical species which attacks cinchona, has been recorded under the name of *Helopeltis febriculosa* Bergroth. The three forms will probably prove to be identical.

This insect forms the worst blight attacking tea, having of late years done enormous damage in certain of the Indian tea districts, especially in the Terai, and in North Luckimpore in Assam. Its effects are very apparent; large areas when badly attacked turning quite black from the injured and destroyed leaves, and the bushes cease to flush for some weeks, or until the blight has partially disappeared, or the bushes have been able to force their growth beyond the power of its attack.

Mr. E. S. Peal, in his report on this blight sent to the Agri-Horticultural Society in 1873, speaks of having carefully watched it for several years, and says that "there can be no doubt that this insect will be the future tea planters' great enemy, if it does not seriously cripple the industry;" the first part of the above has been fully verified in the last year or two, and unless every known means of destroying or preventing the blight are taken soon, the latter part of his warning is also likely to prove correct, as the insect now appears to attack all kinds of tea indiscriminately. An important discovery in the life history of the insect was made by Mr. Wood Mason, who found that the eggs were laid in the young stems or internodes between the leaves, their presence being shown by two hair-like processes, which project from the end of the eggs. These processes are not easily seen as the young stems are themselves covered with hairs. In a report from Mr. R. B. Walker, Doom Dooma, Debrugurh, on the same blight, he says that he found the eggs on the lower and seed-bearing branches more frequently than upon any other part of the bush; he always found the eggs covering *old leaves*, and never on the young shoots, sometines even on the seed itself. This is directly opposed to Mr. Wood Mason's discovery, but it is probable that on badly-blighted bushes the eggs might be found on leaves and stems of all ages, which would account for the fact that hard plucking of the young shoots has not been found an entirely successful treatment.

The insect commences to attack the bushes, when in its youngest stages, by piercing the stem of the unopened leaf bud and the epidermis of the young leaves, and sucking the juices; the puncture first assumes a brown colour, which ultimately turns black, and if they are numerous, the whole leaf shrivels up and assumes the same colour. As new shoots appear from the axils of the leaves below the injured portion, these also are pierced and their growth stopped, until ultimately a broom-like head of blackened stunted twigs is formed, and the bush ceases to flush. The young insect is wingless, and when disturbed is said to fall to the ground; advantage might be taken of this fact to carefully place tarred cloths under the bushes and then to disturb the branches and leaves as much as possible to cause the insects to drop into them; a band of tar might also be painted round the main stem or stems, or a wisp of tarred straw or hay fixed around it, which would prevent the wingless insects from re-ascending the bush; a daily shaking of the bushes for a few days would cause any newly hatched ones to fall off to the ground, where they would be exposed to the attack of ants or birds, &c., and many would be destroyed by being buried when a hoeing was given. It has been recommended that the affected bushes should be carefully examined for the eggs, which should then be treated with some emulsion as kerosine and soap, or other insecticide, which would have the effect of destroying their vitality. This treatment might be adopted at the commencement of the attack with probable success, as there are now several forms of pumps, &c., which can be worked fairly economically, and with which a moderate area can be treated daily, but it is difficult to find the best insecticide which will destroy the vitality of the eggs, without injuring the shoots, or affecting the flavour or quality of the tea.

As regards the use of insecticides for the purpose of killing or driving away the insects themselves, there are no doubt many which would do this, if they remained on the leaves sufficiently long. Unfortunately these blights are at their worst during a period of the year when heavy rain falls almost daily, which completely removes any insecticide that may be applied, unless mixed with some resinous matter, that would cause it to adhere to the leaves for two or three days. With the ordinary method of spraying, the upper surface only of the leaves receives the insecticide to any extent, and the insects can resire within the bush with impunity, and emerge again after the first shower has cleaned the leaves; hence, to be effective, the nozzle of the spraying machine would have to be placed inside the bush, and the spray forced out in all directions, which would saturate the under-surface of the leaves, and at the same time would be less liable to be removed by rain. There are no doubt several practical difficulties, to be overcome in respect to spraying large areas of densely foliated bushes, one of which is the necessity for a large quantity of water for mixing with the insecticide: on some gardens containing several hoolahs interspersed throughout the estate, the difficulty would be at a minimum, but on others every gallon might have to be brought from a distance, which considerably enhances the cost of application. Taking an average garden on which the bushes are planted 4′ by 4′ equal to 2,700 plants per acre, and giving each plant the limited quantity of half a pint, 163 gallons of the solution would be required per acre.

But as stated before if the blight is carefully watched for, and treated immediately on its appearance, the insecticides would only have to be applied over a limited area to prevent its spreading. It is probable that the young insects are found on the bushes by the coolies some days before their effects are visible to the manager; and the coolies and sirdars should be ordered to give the information at once, as the only way to check the blight with any likelihood of success is to take it in its youngest stages, since no insecticides can be applied of sufficient strength to destroy the full-grown winged insect, without injuring the leaves of the plant as well: plucking the young injured shoots may do good to a certain extent by removing many of the eggs, but by the movement of the coolies among the bushes when plucking, the insects are disturbed, and fall to the ground, and are ready to return and attack the new shoots, which have been encouraged by the removal of the others.

Collecting the insects by children has been tried in many instances, with in some cases apparent success, and if adopted immediately on the appearance of the young and wingless insects, a great check could be made on their ravages. To render the remedy most effective, the work would have to be carried out in a thoroughly systematic manner, and this would be best done by staking out the affected part in small plots of from one half to one acre, and placing one or two children on each plot to collect the insects for a few consecutive days. A little extra expense and trouble at this early stage would be better repaid than a larger expenditure of money and labour at a later period.

Flata conspersa, Walker (*Fulgoridæ*).—A small insect reported as attacking tea in the Mungledye district, Assam. It is not thought likely to be of any importance.

Chlorita flavescens, Fabr. (*Jassidæ*).—A small green insect about the size of a house-fly, which is known in Assam as the "blister blight," and in Sikkim as the "green fly blight." It is now very common in some of the tea districts, and does considerable damage, the bushes, if badly attacked, being almost entirely prevented from flushing for some weeks. The insects may be found on the bushes throughout the whole year, and it is probable that the eggs are laid in the young shoots and older leaves. An affected bush can be easily recognized by some of the larger leaves having become doubled back in a peculiar manner, and under which the insects, in different stages of development, can generally be found. This peculiarity makes it very difficult to reach the insects with any insecticides, and they are also uninjured by heavy rain, as the curved leaves completely shelter them. The young insect is greenish-yellow in colour, wingless, and with three pairs of legs, on which it generally moves in a sidelong direction. The head is large, furnished with large compound eyes and long hair-like antennæ, also with a long sucking organ somewhat similar to that of the mosquito blight. As the fly gets older, rudimentary wings appear, which ultimately become developed into two pairs of folding wings rather longer than the body.

Its effect on bushes is to check the growth of the young shoots, owing to the juices being sucked out, and cause them to remain in an undeveloped or *banjy* condition.

Tea made from bushes blighted with green-fly is well known to fetch more in the market than that from unblighted bushes. This is due partly to the slower growth of the leaves, which allows of the fuller development of the flavouring constituent or essential oil, also to the large proportion of unopened leaf buds, which readily assume a golden colour in the manufacture, and add considerably to the appearance of the tea. The blight may be found on all classes of plants, but does most damage to the hybrid and China varieties; it attacks plants of all ages from the seedling in the nursery to old plants, the attack increasing in intensity up to a certain period, after which the plants, if strong and healthy, break through the effects of the pest, and flush more rapidly than ever.

The young wingless insects when disturbed occasionally drop to the ground, but more frequently merely spring from one part of the bush to another, disappearing rapidly to the undersurface of the leaves.

As they are chiefly found on the undersurface of the peculiarly curved leaves mentioned above, when the bush is carefully approached, large numbers could be destroyed by children, if these leaves were suddenly compressed between the hands or flat pieces of wood.

Several are also to be found on the young shoots and leaves when brought by the coolies to the leaf house, and it is probable that several remain in the baskets until taken to another part of the garden, where they can escape on to the surrounding bushes, and so cause the spreading of the attack.

Experiments were made to try the effect of certain insecticides on this insect: a small portion (half acre) of a large area of badly blighted China tea, was treated with a solution of 4 oz. of London Purple in 36 gallons of water.

This was distributed over the bushes in a fine spray by means of a force pump, which effectually moistened all the upper surface of the leaves and shoots of the bushes. For some time the insects appeared to take no notice of the insecticide, but in 24 hours they had almost entirely disappeared from the dressed area, although they were swarming on the surrounding tea. I was unable to discover whether they had been killed or merely driven away for the time, but immediately after the first fall of rain, they returned to the dressed area in large numbers, owing to the insecticide having been almost entirely washed away. Some of the young shoots of the bushes were destroyed by the dressing, but this was probably due to their having received the last of the solution containing an excess of arsenic from the partially-settled sediment.

Although this insecticide can drive green-fly from the bushes, it would never be advisable to use it on bushes that are being plucked for tea. On most gardens the bushes are plucked, if possible, every eighth day, and in some cases more often still, so that traces of the arsenical compound would almost certainly remain on some of the young leaves for that period, and might ultimately be found in the tea. For young bushes in clearances, &c., which are often badly attacked, it might possibly be employed with advantage, but the greatest care would always be necessary to prevent accidents to the coolies, or to stray animals, which might eat the grass jungle on which the insecticide had fallen.

A safer and an equally effectual remedy is the solution known as "Jeye's Insecticide." This was applied at the rate of 1 ℔ to 36 gallons of water to a plot adjoining the above, and had the same result, *viz.*, drove the insects off, until the insecticide had been removed more or less completely by the rain.

The experiments would have been more satisfactory if the insecticides had been received and applied at an earlier date, when the insects first appeared, also if the whole affected area had been treated, but unfortunately this was impossible.

The cost of application is not very great, if water is easily available. To effectually dress one acre of tea (small China bushes) the labour of three men for five hours was required, one being employed in bringing water from a distance of about 100 yards, and the other two being engaged with the pump; the cost per acre for labour would, therefore, be only about 12 annas, but this would be largely increased if water was not comparatively close at hand. To make the remedy effectual, three or more applications would be required, which would necessitate the employment of several men, at a period when they can usually ill be spared from other work, several pumps also would be required to dress even a small area quickly; and where large areas of 100 to 200 acres are attacked, the hand-pump would be practically useless for keeping the blight in check. An effectual distributor, somewhat similar to the horse-power Strawsonizer, to be drawn by a bullock or pony, and which could easily pass between the rows of the bushes on the flat, early in the season, is much required; but one of the difficulties of employing machines of this description is the open drainage system, now so generally adopted, and which would prevent the passage of most implements on wheels, unless the latter were of large diameter. Where however the drains are only of one hoe width, a machine would easily pass over them.

By means of the air blast employed in the Strawsonizer, very small quantities of liquid or powder can be distributed with great evenness over a large area, a gallon of paraffin or other liquid being sufficient to cover one acre with a fine film. For this reason it would be specially suitable for tea, as non-poisonous insecticides could be evenly distributed in a concentrated condition, which would save in carriage of water, and probably be more effectual in destroying or driving away the insects, than when applied in a very diluted state.

Ceylonia theæcola, Buckton (*Aphidæ*).—A minute insect known as the Tea Aphis, which has been found attacking tea in most tea districts, chiefly in the early season. It attacks the young shoots giving them a black appearance from the cluster of minute dark coloured insects, but apparently does little damage. They appear on old and young bushes, and are usually accompanied by black ants, which do not, however, destroy the insects. The few bushes that are generally attacked by these aphides could easily be freed from them by gently rubbing or plucking the young infested shoots and destroying them. An application of phenyle solution is said to kill them. The probable reason of their not having spread more than they have is, that they are subject to numerous enemies as lady birds, parasites, and birds.

Lecanium coffeæ, Nietner (*Coccidæ*).—A minute scale-like insect known as the scaly bug, which is said to have done much damage in Ceylon, but has not been reported as doing any serious harm in India.

Lecanium sp.—Brown bug reported on by Green in Ceylon, is probably the same species. Its attack is followed by a black fungus which, however, does little damage to the leaf.

Lecanium viride, Green (*Coccidæ*).—A minute scale-like insect known as the green scale bug. It is reported to have proved very destructive to coffee bushes in South India and Ceylon. It is also said to be found upon cinchona, lime, orange, and guava plants, and occasionally on tea.

Aspidiotus flavescens, Green (*Coccidæ*).—Known as the yellow bark louse, attacks young tea, forming scales near the axils of the leaves, and said to cause considerable damage in Ceylon from the bushes becoming bark-bound and unproductive. The remedy suggested is to remove all infected wood, and to treat the bushes with kerosine emulsion, which has been found very successful in America for destroying the scale insects that infect orange trees.

Chionaspis theæ, Maskell (*Coccidæ*).—A minute white scale insect which has been reported as attacking tea plants both in the Kangra Valley and Ceylon. I have also seen it occasionally in Upper Assam, but the damage done by it is always very small. This insect also causes the bushes to become bark-bound and to yield small hard flushes, but except in the above-named districts, it has not done much damage. The eggs are laid under the scales of the insects, which, owing to their colour, are not easily observed until they fall off, when they leave a white scale-like mark.

Aspidiotus theæ, Maskell (*Coccidæ*).—Reported as attacking tea plants both in the Kangra Valley and Ceylon.

Aspidiotus transparens, Green (*Coccidæ*).—Said occasionally to attack tea plants in Ceylon, where it has been called the transparent scaled bark louse (Green).

For all the above species of scale insects kerosine emulsions are likely to prove the most effective remedies, as they have been very successfully employed in America.

Leaf Miner, Agromyla sp.—This is often seen on tea, especially on older bushes of the hybrid type, the egg is deposited on the leaf by the fly, and the young larva burrows under the epidermis of the leaves, making several flat tunnels. It is easily seen, and could be destroyed by plucking and burning the few affected leaves.

Red Spider Tetranychus (*bioculatus*).—This insect is present in almost all tea districts, and does considerable damage by checking bushes frequently for weeks at a time during the early flushing season. It is present on the bushes more or less throughout the year, but in greatest quantity in April and May before the commencement of the rainy season. It is generally most prevalent on medium hybrids and China plants growing in low situations, and the spread of the disease was probably greatly due to the want of proper drainage in the soil, whereby the plants became stunted and bark-bound, and consequently more liable to insect or other blight attacks. At the present time it may be found on tea both in high and low situations, under shade or where no shade is near. Tea bushes situated near the coolie lines are almost certain to be attacked with it, and this is probably due to the coolies having carried the eggs or spiders on their clothes from other affected parts. These bushes, however, rarely seem to suffer much from the effects of the blight, as the soil is always in good condition, and they are able to throw off the effects of the attack. Where the soil is in poorer condition, the bushes are far more affected, the older leaves assuming a dry hard appearance and character, by which absorption of atmospheric food is largely prevented, and the bushes cease to flush. Insecticides applied in the ordinary manner are apparently of little benefit, as the spider can retire under the fine mesh of its web, and be quite free from injury. The eggs, which are almost globular with a small hair-like projection in the centre, are laid near the veins of the leaves, and can be easily distinguished with the aid of a magnifying glass, together with the numerous white cast skins of the spiders themselves.

Removal of all affected leaves during the cold weather and burning seems the only effective way of treating the disease, but dressing the bushes with dry quicklime or some insecticide which would destroy the vitality of the eggs might be tried with possible advantage.

It is useless pruning the bushes severely, and then leaving the prunings lying on the ground until the leaves, on which the eggs are laid, have dropped from the branches; the prunings must be removed at once, and burned or buried at a depth from which they will not be brought again to the surface during the ordinary processes of cultivation. Liming the main stem and any remaining branches would destroy any eggs that might be present on them.

Potassium Sulphide has been found very useful for red spider, fungoid growths, and other blights on plants. A solution of ¼ to ½ an ounce per gallon is generally sufficient; from 5 to 6 lbs., which would cost from 3 to 4 rupees, would be sufficient for one acre.

Dusting the leaves when moist with sulphur has been tried in the Darjeeling district on a large scale, and with apparent success, the sulphur being probably slowly converted into sulphurous acid by the action of the air, which is poisonous to plant and animal life. When washed off the leaves by the rain, it would slowly become converted into sulphuric acid in the soil, where it would be utilized by the plant to supply the sulphur required for certain of its constituents, as legumin, which forms one-fourth of the dry substance of the leaf.

PSEUDONEUROPTERA.

Termitidæ.

Termestaprobanes, Walker.—The common white ant of Lower Bengal, very destructive to inferior timber and other dried vegetable matter, also attacking young and unhealthy plants, and is probably the species attacking tea plants in most tea districts. This pest is common in all the tea districts either in the hills or plains, and often does considerable damage, by cutting galleries within the stem of the plant, either killing it outright, or making it unproductive. The winged insects may be seen flying in swarms during the evening, at a certain season of the year attended by birds and bats, which destroy large numbers of them. After a short flight they fall to the ground, where they are said to be found by the worker ants and carried underground, and deposited in chambers where the queen lays her eggs, which produce numerous new males and females. The queen-ant lives several years, and produces an enormous number of young, hence the necessity of destroying it, whenever it can be found.

When working on the outside of a bush or stump, the ants make a covering of earth to hide their operations. These should be removed as soon as observed, and the parts dressed with petroleum or earth-oil.

In new clearances, ant-hills are fairly common, and it is curious that tea will not grow either on the hill, or where it has been cleared away, unless heavy manuring is done, and the soil thoroughly pulverised.

It is most important that all ant-hills should be destroyed, especially when near a nursery or young plantation, as if the plants are attacked at an early stage, and the main stem at all damaged, they will never recover and yield the same as an uninjured plant.

It might be possible to destroy the ants before they take flight by burning sulphur or other material in such a manner, that the gases and smoke would penetrate the numerous passages of the hill, and either cause the ants to emerge or smother them inside. Such a remedy could be easily tried, and would be far less laborious and expensive than cutting away the mounds, some of which are of great size.

Fires of brushwood could be lighted on the windward side, and either sprinkled with sulphur or covered with damp jungle or straw and old bamboo mats, to assist in forcing the smoke into the interior.

Small quantities of heavy earth-oil poured into holes bored in the mounds in a sloping direction would also, when burning with a limited supply of air, cause a heavy smoke to penetrate throughout. Owing to their unsightliness the mounds are often levelled, but there always remains an unproductive bare piece of ground, larger than the area of the base of the mound, owing to the earth which has been thrown over the surrounding soil.

Besides the numerous insect enemies already mentioned, the tea plant is subject to the attack of many fungoid growths, some of which do a great amount of damage, often killing the plants completely; while others cause a toughening of the bark, which reduces the plant to such a condition that all healthy growth is checked.

One of the most important is a minute brown fungus, which eats into the main roots of the plant just beneath the surface of the soil. As a rule, there is nothing to be *easily* seen on the stem or branches of the bush to indicate the injury that is proceeding beneath the soil; but a very close examination of some of the smaller branches generally reveals small bright red patches, which under the microscope are seen to be minute coral-like fungoid growths, totally different in appearance to the fungoid attacking the plant beneath the soil. It was impossible to trace any connection between the two by the most careful examination, and their presence on the same bush may be merely a coincidence as they were not invariably to be found together; but in every case examined, where the coral-like fungus was on the branches, the brown fungus was also on the roots.

The latter fungus in its growth causes a rapid decay of the outer covering of the root, while the internal woody portion becomes hard, dry, and of a dark-brown colour.

The first visible indication of the attack is the sudden drooping and drying up of the leaves, and in a very short period the whole plant dies, apparently from the flow of sap being checked by the fungus penetrating and choking the sap-carrying vessels.

The plants most usually attacked are those of about three years of age, just at the period when they are commencing to yield, consequently if many are attacked the loss is very serious.

The progress of the disease is so rapid, when once the signs are visible above ground, that there is little chance of applying an effectual remedy in time to save the bush, and probably by that time the roots have been injured beyond recovery.

Clearing away the soil from the upper part of the main root, scraping off the fungus, and applying a thick coating of quicklime and sulphur, would kill the fungus (the above mixture having been found very efficacious for fungoid growths in Ceylon), and give the plant a slight chance of recovery.

The cause of the disease is doubtful, but it is evidently not due to poverty of soil or want of drainage, as plants growing on good, well-drained, light, loamy soils are often attacked.

It may be due to the slow decay of certain forest-tree roots which have formed a nidus for this particular fungus, and from which it has gradually spread through the surrounding soil, and this view appears to be borne out by the fact that the disease is only prevalent on forest soil, and always appears the third or fourth year after clearing, by which time the hardest roots would have undergone decomposition.

To prevent the spread of the disease as much as possible, all bushes that have died from it should be removed from the soil and burned; and before the vacancy is refilled with a new plant the surrounding soil should have a good dressing of quicklime thoroughly incorporated with it, so as to destroy any remaining spores or filaments which would attack the young plant.

Another fungoid growth attacking tea, and which is prevalent in all the tea districts, is a white thread-like plant, growing only on the branches.

This fungus does not kill the plant completely, but only the stem or branches on which it grows, and which can be easily distinguished from a distance by the dried-up appearance of the leaves.

In growing, it spreads over the stems frequently from near the base of the bush up to the extremities of the young shoots, which rapidly dry up from the absorption of the juices of the plant.

The cause of this disease appears to have been originally due to a want of drainage in the soil, by which the plants were rendered unhealthy, and so more liable to attack ; but it is difficult to say by what means it spreads, unless it is by spores, carried by the wind or birds, or on the clothes of the coolies. A single bush may be attacked in the centre of a large area of healthy bushes, none of the others being affected during the same year ; but it has been found by experience that, if the diseased bush is left, the neighbouring bushes are often attacked during the following season, until a large area may be affected by the disease. As its effects are easily seen, and as a rule, only a few bushes on a garden are attacked at first, the disease can easily be checked and eradicated by carefully removing the affected branches, and burning them.

Scraping off the fungus from a newly-affected branch, and applying a coating of lime or other suitable material as paraffin or petroleum oil, might enable the branch to be saved, if taken in time, and this could be best effected by instructing the sirdars or coolies to remove the fungus on its first appearance, the latter, from always working among the bushes, being best able to detect it.

There are a few other fungoid growths to which tea is subject, but none of them are of much importance. One is a minute black thread-like fungus when viewed under the microscope, and appears in small black patches on the older leaves of the bushes, chiefly near jungle or bamboo forests. It is common in most tea districts on bushes of the China or hybrid varieties, more rarely on the indigenous Assam variety, and would be best cured by heavy pruning, and destroying the prunings, and giving the plants a good dressing with rich bheel soil, or cattle manure, to assist in a more rapid growth—slow-growing plants on poor worn-out soil being those chiefly liable to the attack, which from their unhealthy state, they are unable to throw off.

Lichens and certain mosses are also found on tea, chiefly on old bushes, which have been stunted or checked in their early growth by the presence of stagnant water in the soil. The only remedy for this is thorough and efficient drainage, which will remove all stagnant water from below the lowest roots, scraping the affected stems, without removing the bark, by rubbing with coarse cloth or cocoa-nut fibre, and finally by covering the cleaned stems with a freshly prepared mixture of quicklime and water.

Heavy pruning and manuring after the drainage has been done will often enable the bushes to throw out new straight wood, but the plants will never become as healthy as those which have at no period been checked throughout their growth. The necessity of good drainage being given before the roots of the young plants have penetrated to any depth is therefore apparent, as no after-treatment will enable them to regain their former vigour.

APPENDICES.

APPENDIX I.

MR. DUNN'S ANALYSES OF CEYLON TEA, 1880.

Industrial and Technological Museum Laboratory.

Marks.	Name.	% Ash.	% Extracts.	% Soluble Salts.	% Theine.
81	Orange Pekoe	4.60	44·80	3·06	2·15
82	Pekoe	4·92	43·80	3·32	1·82
83	Pekoe Souchong	5·04	42·80	3·12	1·86
84	Souchong	4·84	40·40	3·20	1·84
85	Congou	4·80	37·40	2·96	1·82
86	Green Tea	4·72	44·00	2·66	·94

REPORT ON 15 SAMPLES OF INDIAN TEAS BY J. COSMO NEWBERY.

	Name.	% Ash.	% Extracts.	% Soluble Salts.	% Theine.
20	Dooars Pekoe Souchong	5·20	40·97	3·08	2·86
16	,, Bro. ,, ,,	5·10	36·11	3·10	2·42
11	Darjeeling Pekoe	5·16	38·97	3·16	1·96
23	,, ,, ,,	5·36	41·80	3·20	1·96
15	,, ,, ,,	5·40	36·08	3·04	2·36
17	,, Souchong	5·22	36·99	3·02	1·66
26	,, Pekoe Souchong	5·66	39·40	3·46	2·24
10	Assam ,, ,,	5·20	40·12	3·04	1·66
25	,, ,, ,,	5·52	38·60	3·32	1·84
19	,, Souchong	5·20	39·27	3·00	1·46
27	,, Bro. ,,	5·60	39·40	3·20	1·98
28	Cachar Pekoe	5·22	43·85	3·22	1·58
24	,, Bro. ,, Souchong	5·36	38·88	3·18	1·92
29	,, Pekoe ,,	5·64	40·66	3·24	1·44
22	,, Souchong	5·36	40·29	3·12	1·76
Av. of above 15 Samples		5·34	39·42	3·16	1·94
Av. of 15 Samples of Foochow Congous		5·20	29·26	2·88	1·84

APPENDIX II.

Extract of Dr. Diver's paper on "The Chemical Composition of Japan and other Tea."

The following analyses of Japanese Tea, made in the laboratory of the Imperial College of Agriculture, Tokiyo, were published in 1879 by Mr. Edward Kinch, then Professor of Chemistry there, and now in the same position in the Royal Agricultural College of England:—

	I.	II.	III.
Water	6·74	6·10	8·92
Fibre	11·20	11·70	
Ash	6·53	6·10	5·26
Soluble in water	43.26	52·55	36·50
Tannin	12·50	12·10	13·19
Nitrogen	5·79	6·33	3·18

These quantities refer to 100 parts, and are not to be added together, because the matters enumerated are not exclusive of each other; part of the ash, part of the nitrogen, and all the tannin being contained in the matter soluble in water. No. 1 is Hiki-cha or ground tea, from Uji, for eating with its infusion in the form of a broth. No. 2 is Sen-cha or leaf tea, for infusing in the ordinary way, also from Uji. No. 3 is made by the Chinese method at the experimental section of the Agricultural Bureau, Naito Sinjiku Gardens, Tokiyo. Eder gives a summary of his examination of various teas, Chinese, Japanese and Indian, of which the following is an extract:—

Water	10	
Soluble matters	30	
Tannin		10·0
Theine		2·0
Tea-oil		0·6
Legumin (albuminoids)		12·0
Mineral		1·7
Other substances		3·7
Insoluble matters	60	
Albuminoids		12·0
Wax		·2

Resin	3·0
Cellulose	20·0
Mineral	4·0
Others	20·8

The desired effects of tea-drinking are almost certainly due to the hot drink in the first place, and then to the tannin, the theine or caffeine, and the fragrant oil and resin in the tea.

When the tea comes hot from the firing operation it is without any water, and if at once packed in really air-tight cases, will remain so. Even by some exposure, as by keeping in common tin canisters, it may remain a long time with only 2—4 per cent. of moisture absorbed, as my own analyses show. But analyses of tea in Europe have been published giving as much as 16—17 per cent. of water; and 10 per cent. is regarded there as the normal content. Thus it will be seen that every nine pounds of tea put up in Japan or China will, on retailing in the United States or Europe run to ten pounds. The tea containing the water remains dry to the touch. Another point of interest attaching to this water is that in its absence, the spores of must and mould are inactive, while they at once find a congenial seat of growth, when they fall in with tea containing a tolerable quantity of moisture, especially when the tea has been lightly fired as by the Japanese method only.

With regard to the theine and volatile oil and resin, it is certainly of interest to note, that while these are very active physiological agents, and undoubtedly give to tea much of its esteemed qualities, the quantities of these constituents,—of the theine at least, have not been found to be at all in any direct relation to the recognised value or appreciation of the tea. Theine is also found in coffee, and as far as the possession of this substance is measured, it may be said that one ounce of tea is equal to at least two ounces and a half of coffee. Two per cent. is the usual proportion of theine in tea. (Improved methods of estimation have shown this to be too low.) *Tea-oil* does not exist in the fresh leaves, but is developed by a species of fermentation after they are gathered. The resin appears to be the substance into which the oil changes by time. When this change is complete, the tea has lost its aroma. According to the earlier determinations by Mulder, Chinese and Java tea contained less than 1 per cent. of theine. Subsequently Stenhouse found from 1—2 per cent in a number of samples examined by him, while Peligot obtained from 2·5 to 4 per cent., and in one case as much as 5·84 per cent. The methods adopted to obtain these results were probably inadequate on the one hand to obtain theine in a sufficiently pure condition, and on the other to extract the whole of it in such a condition. Even Zöller's more recent examination of a sample of tea from the Himalayas, in which he found 4·94 per cent. theine, does not sufficiently remove uncertainty as to the amount of theine in average tea, for his memoir suggests that the tea examined by him was of exceptional quality.

Liebig was of opinion that theobromine was also obtained from the Himalaya tea, examined by Zöller, though this point was not settled conclusively, since the quantity of material was too small for the purpose. In two other samples Zöller was unable to find any trace of theobromine, and Messrs. Paul and Cownley who have always endeavoured to trace the presence of theobromine have always met with negative results. But, as the quantity of tea operated upon for the determination of theine is but small, a minute proportion of theobromine might in that case have escaped detection. The amount of theine in tea is by no means a constant quantity, and, so far as the tea of India and Ceylon is concerned, varies from 3·22 to 4·66 per cent., while in coffee the amount is more constant.

The following table gives the results of determinations in twenty-eight samples, varying greatly in quality and price, 7*d*. to 3*s*. per lb.

The sample No. 10 was tea of exceptionally fine quality, that was valued at 6*s*. or 7*s*. per lb. and the sample No. 4 consisted of the hairs detached from the leaves in sifting:—

	Ceylon Tea	Approx. elevation of place of growth, ft.	Moisture per cent.	*Theine per cent.* Original Tea.	*Theine per cent.* Dry Tea.
1	Penhros ...	2500	6·8	4·56	4·89
2	F. L. C. ...	....	6·0	4·56	4·85
3	Nahalma ...	300	5·6	4·54	4·80
4	Hairs from tea leaves	....	6·6	2·40	2·57
5	Hardenhuish Pekoe	3500	3·8	4·08	4·24
6	Woodstock Pek. Souch.	4200	3·6	3·44	3·57
7	Radella Bro. Pek. ...	4800	4·6	4·10	4·30
8	Morton Pekoe ...	400	4·2	3·98	4·15
9	Penhros Bro. Pek. ...	2500	6·4	4·64	4·96

V

	Ceylon Tea	Approx. elevation of place of growth, ft.	Moisture per cent.	Theine per cent. Original Tea.	Dry Tea.
10	Strathellie Or. Pek....	2000	5·4	4·10	4·33
11	Nahalma Or. Pek. ...	300	5·4	4·06	4·29
12	Venture Or. Pek. ...	4300	5·4	3·74	3·95
13	St. Leys Pek. Dust. ...	4600	5·6	3·46	3·66
14	Venture Pek. Souch.	4300	4·8	3·40	3·57
15	Venture Bro. Or. Pek.	4300	6·6	3·98	4·26
16	Calsay Pek. Souch....	5000	6·2	3·22	3·43
17	Venture Pekoe ...	4300	5·6	3·48	3·68
18	St. Clair Or. Pek. ...	4200	4·6	3·90	4·09
	Indian Tea.				
19	Pekoe tips picked out	....	7·56	4·27	4·62
20	Broken Pekoe ...	....	7·00	4·48	4·81
21	Pekoe ...	....	6·40	4·16	4·44
22	Orange Pekoe ...	....	4·80	4·66	4·89
23	Pekoe ...	....	5·60	4·48	4·74
24	Broken Pekoe ...	....	4·80	3·76	3·95
25	Pekoe ...	....	5·40	3·66	3·86
26	"Weak" tea ...	....	6·80	4·06	4·35
27	"Strong" tea ...	....	5·80	4·18	4·43
28	Mixture ...	....	6·00	3·64	3·87

So for as the tea of India and Ceylon is concerned, it is at least evident from the data above given, as compared with the prices mentioned, that the marketable value of tea is not to any great extent dependent on, or proportionate to, the amount of theine it may contain, however important that constituent may be in other respects. Neither can the "strength" of tea, as that term is generally under stood, be taken as proportionate to the amount of theine, which is evident from the results 26 and 27 in which the difference is very slight.

APPENDIX III.

Composition of Tea Leaves. By O. Kellner (Landw. Versuchs—Stat. 1886. 370—380), and Journal of the Chemical Society, 1887.

THE Author has systematically examined the green leaves throughout the year as follows: The leaves were dried at 66°—80°, and the total nitrogen estimated by soda-line, whilst the Albuminoid nitrogen was determined by a modification of Stutzer's process, because theine-tannate is only decomposed with difficulty and at 100°; also the filtration of the solution is attended with great difficulty. Two grams of the substance were boiled with 100 c c of Water, 20 c c of a 10% $CuSO_4$ solution added, and the Copper precipitated by a titrated solution of Caustic Soda still leaving a small quantity of Copper in solution, the precipitate was washed with hot water, and finally with 95% Alcohol. The filtrate runs quickly through the paper and is free from albuminoids. The total soluble matter was estimated indirectly, 3 grams being repeatedly boiled with water, and the residue weighed.

Theine was estimated in 5 to 7 grams which were boiled in water, the solution evaporated and Magnesia usta added, gently dried, and the residue extracted with ether.

To obtain the tannic acid, which owing to the presence of pectin could not be filtered in the usual way, the leaves were extracted with alcohol acidified with a few drops of acetic acid, the solution thus obtained evaporated, and the residue dissolved in water, and filtered through asbestos. In calculating the results, 63 parts of oxalic acid were taken to be equivalent to 34·25 gallotannic acid; the tannin in tea being identical with that acid. The composition of the leaves is shown in the accompanying tables. Non-albuminoid nitrogen is almost entirely absent during the later stages of growth, being found as theine. Connecting this with the fact that albumin has increased, and that no theine is found in the seeds, the author believes that positive proof is afforded that the alkaloid, like glutamine and asparagine, is a decomposition product of albumin, and is capable of again forming albumin.

The ash increases regularly during the season.

Percentage on Dry Matter.

Date.		Water in fresh leaves.	Crude protein.	Crude fibre.	Etherial extract.	Cellulose &c.	Ash.	Theine.	Tannin.	Soluble in hot water.	Total nitrogen.	Albuminoid nitrogen.	Theine nitrogen.	Amido nitrogen.
May	15	76·83	30·64	9·10	6·48	49·09	4·69	2·85	8·53	36·18	4·91	3·44	·81	·66
,,	30	75·78	24·25	17·23	6·42	47·32	4·76	2·80	9·67	37·17	3·88	2·77	·79	·32
June	15	78·61	22·83	17·38	6·05	48·26	4·88	2·77	10·10	36·12	3·65	2·73	·78	·14
,,	30	70·85	21·02	18·69	6·83	48·50	4·96	2·59	10·25	36·06	3·37	2·43	·73	·21
July	15	72·67	20·06	19·16	7·00	49·49	4·29	2·51	9·40	31·72	3·21	2·31	·71	·21
,,	30	70·54	19·96	17·56	8·59	49·43	4·46	2·30	10·44	33·77	3·19	2·25	·65	·29
Aug.	15	64·21	19·05	17·72	10·85	47·80	4·58	2·30	10·75	32·70	3·05	2·28	·65	·12
,,	30	67·75	18·58	17·95	12·14	46·35	4·98	2·22	11·09	34·00	2·91	2·1[illegible]	·63	·16
Sept.	15	65·26	18·27	19·13	13·40	44·35	4·85	2·05	11·32	30·01	2·93	2·27	·59	·08
,,	30	64·20	18·15	19·17	14·16	43·41	5·11	2·06	10·91	33·05	2·91	2·39	·58	...
Oct.	15	64·66	17·91	18·66	17·23	41·14	5·06	1·83	11·21	34·76	2·87	2·45	·52	...
,,	30	64·11	17·98	18·40	19·50	39·05	5·07	1·79	11·27	36·80	2·88	2·35	·51	·02
Nov.	15	59·43	17·70	18·26	20·38	38·66	5·00	1·30	11·34	38·21	2·83	2·30	·37	·16
,,	30	60·97	17·14	18·34	22·19	37·31	5·04	1·00	12·16	37·91	2·74	2·35	·28	·11
May	15 ... ... Old leaves.	60·03	16·56	17·62	14·18	46·50	5·14	0·84	11·11	36·45	2·07	2.43	·23	·01

In 100 parts of pure Ash.

Date.		K_2O.	Na_2O.	CaO.	MgO	Mn_3O_4	Fe_2O_3	P_2O_5	SO_3	SiO_2	Cl.
May	... 15	49·06	1·07	11·95	8·69	1·64	3·80	16·67	3·75	2·34	1·04
,,	... 30	46·33	2·00	14·93	9·00	1·79	4·30	15·63	3·61	1·24	1·39
June	... 15	41·37	1·23	17·70	11·72	1·98	6·55	13·76	3·21	1·60	1·06
,,	... 30	37·09	1·59	21·95	11·67	1·30	7·25	13·35	3·56	1·41	1·18
July	... 15	35·76	1·58	22·04	12·21	1·58	8·48	12·41	3·37	1·62	1·17
,,	... 30	32·84	·80	22·88	12·91	1·75	9·75	12·33	3·83	1·35	1·22
Aug.	... 15	31·01	1·08	23·24	13·71	1·21	12·14	12·00	3·43	1·02	1·14
,,	... 30	29·15	1·14	22·20	14·79	1·57	11·02	11·71	3·81	2·72	1·13
Sept.	... 15	23·72	4·77	23·44	14·74	1·72	11·64	11·25	4·74	1·69	1·58
,,	... 30	22·28	2·06	27·71	15·80	1·63	12·11	11·52	4·08	2·17	1·35
Oct.	... 15	20·97	2·76	27·90	15·88	1·37	11·83	10·71	4·37	2·61	1·11
,,	... 30	19·75	2·72	28·75	17·19	1·53	11·63	10·23	4·01	2·44	1·38
Nov.	... 15	18·67	2·76	29·60	17·39	2·06	11·37	10·70	3·84	1·75	1·09
,,	... 30	17·31	2·02	30·37	17·99	2·48	11·02	10·96	4·02	2·79	1·19
May (Old leaves.)	... 15	14·20	3·21	30·36	18·49	2·82	11·93	10·64	4·41	2·13	1·32

APPENDIX IV.

Extract of a letter from the Sub-Divisional Officer, Sunamganj to the Deputy Commissioner of Sylhet, a copy of which was forwarded for information to the Deputy Secretary of the Agri. and Horticultural, Society of India, giving all information as to the purchase and delivery of Sylhet lime to different tea districts :—

1. The percentage of quick lime obtained from the stone is a little below 50 per cent.

2. The cost per 100 maunds of quick lime on boats (exclusive of the price of earthen jars in which it is put) to Budderpur, Silchar, and Lakhipur is Rs. 112, 120, and 128, respectively.

3. The freight of boat per 100 maunds from Chhattak to Budderpur ranges from Rs. 15 to 20, to Silchar from Rs. 20 to 25, and to Lakhipur from Rs. 25 to 30, during the rains, and about Rs. 5 more during the dry season.

4. Quick lime is carried in country boats put in earthen jars.

5. Quick lime is obtainable from November to February only.

6. The size of the boat varies according to the season of the year. During rainy season big boats carrying from 500 to 100 maunds are employed: during the dry season, when the river falls, small boats of 100 to 50 maunds burden are used.

7. The trade of slaked lime exists throughout the whole year, and orders may be sent to the following persons :—

(1.) Syam Sundor Das, Gomasta of Lakhikanta Roy, Chhattak.

(2.) Nobin Chundra Surma of do.

(3.) Bhagaban Chundra Rai, Gomasta of Parmeswari Chaudhurani, Dowra Bazar.

(4.) Ram Kesab Rai of Sunamgaj Bazar.

(5.) Rai Chand Rai of do.

Of these Nobin Chundra Surma and Bhagaban Chundra Rai use to comply with orders everywhere.

I have, &c.,

(Sd.) J. B. Nag,

Sub-Divisional Officer.

APPENDIX V.

Table showing in parts per 100,000, and grains per gallon the amount of Ammonia (NH_3), Nitric Acid (N_2O_5), and Chlorine, (Cl) as common salt (NaCl) in the rainwater of Calcutta, collected at the Alipore Observatory from May to October 1891.

		Parts per 100,000.				lbs. per acre.			
Date.	Rain-fall.	NH_3	N_2O_5	Total Nitrogen as NH_3	Cl as NaCl.	NH_3	N_2O_5	Total N as NH_3	Cl as NaCl.
May 24th	2·12″	·0216	·0540	.0233	—	·095	·240	·166	2·40
June 4th	2·93″	·0220	·0595	·0407	·500	·147	·400	·273	5·50
8th	2·86″	·0200	·0496	·0356	·807	1·30	·326	·232	5·37
30th	1·79″	·0150	·0480	·0301	·708	·060	·197	·123	2·90
July 4th	1·79″	·0200	·0480	·0351	·300	·081	·197	·143	2·06
14th	1·63″	·0230	·0400	·0356	·797	·085	·147	.131	2·85
23rd	1·24″	·0120	·0640	·0320	·494	·034	·181	·091	1·40
31st	3·93″	·0400	·0480	.0551	·593	·358	·430	·493	3·21
Aug. 8th	2·70″	·0240	·0400	·0596	·548	·148	·246	·225	3·19
15th	7·48″	·0090	·0640	·0290	·420	·153	1·091	·496	7·16
31st	2.30″	·0480	·0050	·0496	·550	·252	·085	·519	2·88
Sept. 16th	5·80″	·0080	·0200	·0140	·336	·106	·266	·190	4·39
Oct. 22nd	3·55″	·0300	·0280	·0388	·494	2·42	·225	·312	3·99
Total	40·12″	·2926	·5682	·4785	6·547	1·892	4·021	3·394	47·30

APPENDIX VI.

Extracts &c. from letters received from Managers and Agents who had made certain manurial experiments :—

Durrung.—The saltpetre applied to the bushes in 1891 failed to increase the outturn.

Darjeeling Tea and Cinchona Association.—Two acres were manured with bone dust, 6 cwts. to the acre. The cost of the manure was Rs. 35, and the freight and application to the soil would probably come to a further Rs. 35. The yield compared with two adjoining acres, of which a careful record was kept, was about 1 maund of tea in excess of the unmanured portion. The manure was applied in April. and seems to have had an immediate effect, as the crop of leaf in May was larger over the experimental acres than over the unmanured plot.

Dooria Tea Estate.—Certain experiments were made by Mr. W. Hutchison to try the effects of the ash of tea prunings, unslaked lime, and bheel soil from the Hullahs. The quantities applied to the different plots were : 1lb. of lime per bush, 1lb. of ashes, and the bheel soil 3 inches thick over the whole surface of the soil.

The latter plot derived the most advantage, then the lime, and lastly the ashes. All the plots were attacked with green fly, but owing to the vigorous growth on the one top-dressed with bheel soil, it had not in that case the same lasting effect.

Sissubari, Julpaiguri, Dooars.—"Wood ashes from the engine, mixed with cow, dung and applied immediately after the hoe succeeding the pruning, had a beneficial effect, the bushes became much more vigorous than before, and the yield was better. It was also found that burning the prunings immediately on being cut, and better drainage, had the effect of keeping blight in check, causing it almost entirely to disappear from an old garden, which previously suffered severely with it.

Khoniker Tea Estate, Assam.—Mr. F. C. Moran found that lime broad cast on poor land was most advantageous, the plants thriving and coming on with vigour after an application, the quantity used being about 20 maunds lime to an acre. A small piece of tea about 2 acres that had not come on for years, after an application made good growth, and yielded flush for flush with the rest of the garden. Mr. Moran is also of opinion that, when mosquito blight is bad, the bushes cut down and whitewashed, and the land sown with lime, which is well mixed with the soil, in a manner stops the blight to a very great extent, if not altogether. The price of lime being so very high prevents its being used largely, but Mr. Moran is convinced all old gardens (20 years and upwards) would benefit greatly if sown with it.

Experiments on the Oaks Tea Estate, Darjeeling.—It was found that Native Guano, the composition of which is given under the head of manures, gave no improvement when applied at the rate of 10 maunds per acre, and only a slight increase of leaf when applied at about one ton per acre.

Cow dung was found to give an increase of 25 per cent. first the year of application, and a slight increase also during the second year

Animal charcoal was found to give an increase during the first year when applied at 2 oz. per bush.

A mixture of bone dust 100 maunds, sulphate of potash 20 maunds, and lime and ashes 30 maunds, applied at the rate of 4 oz. per bush, was also found to cause a slight increase.

APPENDIX VII. (*a*).

—o—

SILCOORIE EXPERIMENTS, CACHAR.

Table 1 showing the return of leaf from ½ acre plots on which Chemical manure was applied in 1891.

No. of plots.	Description of manure applied.	Yield in leaf. Mds.	srs.	Appearance of plot.	Outturn per acre. Mds.	srs.
1	1 cwt. Nitrate of Potash	8	17	Best appearance, generally very good growth	16	34
2	1 ,, Do. and 1 cwt. Bone dust	9	20		18	40
3	5 cwt. Oil cake, 1 cwt. Sulphate of Potash, and 1 cwt. Bone dust	10	9	Appearance hardly equal to Nos. 1 and 2, more blight ...	20	18
4	1 cwt. Bone dust ...	7	10	Worst of all, badly blighted	14	20
5	1 ,, Do. and 5 cwt. Oil cake	8	10	Much the same as 3 and 4	16	20
6	1 cwt. Sulphate of Potash	7	10		14	20
7	1 ,, Do. and 1 cwt. Bone dust ...	6	14	Slightly inferior to above, bushes are smaller than in other plots...	12	28

Taking Nos. 4 to 7 as equal to the unmanured plots the average is 14 mds. 11 lbs. per acre, green leaf=3 mds. 43 lbs. per acre tea

or. $3\frac{10}{20}$ mds. per acre. mds.

Plot 1 = $4\frac{2}{20}$,, ,, ,, = gain $\frac{12}{20}$ at a cost of Rs. 19
,, 2 = $4\frac{12}{20}$,, ,, ,, = ,, $1\frac{2}{20}$,, ,, ,, 28
,, 3 = $5\frac{1}{20}$,, ,, ,, = ,, $1\frac{11}{20}$,, ,, ,, 35

Average price per lbs. @ 7 annas = Rs. 35 per maund—

Plot 1 $\frac{12}{20}$ md. = Rs. 21-0 — Rs. 19 manure = Rs. 2-0 profit.
,, 2 $1\frac{2}{20}$,, = ,, 38-8 — ,, 28 ,, = ,, 10-8 ,,
,, 3 $1\frac{11}{20}$,, = ,, 54-4 — ,, 35 ,, = ,, 19-4 ,,

Plot 1 19 : 100 :: 2 : 10·5% profit. Int. on outlay
,, 2 28 : 100 :: 10·5 : 37·5% ,, ,, ,, ,,
,, 3 35 : 100 :: 19·25 : 55 % ,, ,, ,, ,,

APPENDIX VII. (*b*).

—o—

Silcoorie Experiments.

Table 2 showing the return of leaf from ½ acre plots for 1891 and 1892, Chemical manure being applied in the former year only.

		1891.		1892.		
	7½ acre plots of 1891—					
1	1 cwt. Nitrate of Potash	8	17	16	33½	Well grown, but blighted badly later on in season.
2	1 ,, Ditto ... } 1 ,, Bone Meal ... }	9	20	9	21½	Also well grown, rather less blight than No. 1.
3	5 ,, Oil cake ... 1 ,, Sulphate of Potash ... 1 ,, Bone Meal ...	10	9	16	7½	Growth and appearance not so good as Nos. 1 and 2, about the same blight.
4	1 ,, Bone dust ...	7	10	8	16	About the same growth as No. 3, but this plot is handicapped by having a large paple tree, in it, round which there is always blight.
5	1 ,, Bone dust ... } 5 ,, Oil cake ... }	8	10	14	28	Fair growth, good appearance generally, very little blight.
6	1 ,, Sulphate of Potash ...	7	10	14	31½	Very little growth but not much blight.
7	1 ,, Ditto ... } 1 ,, Bone dust ... }	6	14	7	0	Rather similar in appearance to No. 6, but this plot is not equal as regards size or number of bushes to the others.

Top dressing with lime Silcoorie	This was done in several parts of the garden, both tillahs and flat, unslacked lime being used on the heavier soils and slacked lime on the sandier, the separate outturns could not be kept, but the result, especially on the heavier soils, as far as appearance of plant and apparent outturn from the several bushes went, was satisfactory, with the exception of one sandy flat to which slacked lime was applied, and in which there is little apparent result.

Silcoorie:
28th December 1892.

(Sd.) W. T. CATHCART,
Silcoorie, 20th December 1892.

APPENDIX VII.—(c)

Silcoorie Experiments.

Table 3, showing return of leaf from 1 acre plots manured in 1892.

No. of Plot.	Description of manure applied.	Yield in leaf per acre.		
	Three Plots of 1892.	Mds.	Srs.	
1	2 cwt. Nitrate of Potash 1 cwt. Superphosphate 2 cwt. Bone meal	27	17	This is the least grown of the three plots and has most blight, though not equal to the others. This plot has fair growth, and is not really badly blighted.
2	8 cwt. Rape cake ... 1 ,, Nitrate of Potash 2 cwt. Bone meal ...	29	12	Good appearance, well grown, slight blight.
3	Unmanured ...	27	6	Good appearance and growth.

APPENDIX VII.—(*d*)

Table showing the valuations of Tea manufactured from the Silcoorie Experimental Plots.

Manure.	Pekoe.	Broken Pekoe.	Pekoe Schg.	Souchong.
1. Nitrate of Potash 3	8	$12\frac{3}{4}$—13	$5\frac{1}{2}$ $5\frac{3}{4}$	5 —$5\frac{1}{4}$
2. Nitrate of Potash and 3 Bones.	2 · $8\frac{3}{4}$	$11\frac{1}{4}$	$5\frac{3}{4}$	5
3. Oilcake, Sulphate of Potash. Bones ...	3 $8\frac{1}{4}$—$\frac{1}{2}$	$10\frac{3}{4}$—11	$5\frac{3}{4}$	5 —$5\frac{1}{4}$
	$8\frac{1}{4}$—$8\frac{1}{2}$	12	......	5 —$5\frac{1}{4}$
4. Bones ...	4 $8\frac{1}{4}$—$8\frac{1}{2}$	12	$5\frac{3}{4}$ 16	5
5. Oilcake ... Bones ...	8 —$8\frac{1}{4}$	$11\frac{1}{4}$	$5\frac{1}{2}$	5
6. Sulphate of Potash	8	$10\frac{3}{4}$—11	$5\frac{3}{4}$	5
7. Sulphate of Potash and Bones	$8\frac{1}{4}$—$8\frac{1}{2}$	12	$5\frac{3}{4}$ 6	5 —$5\frac{1}{4}$
8. Unmanured ...	8 —$8\frac{1}{2}$	$10\frac{3}{4}$—11	$5\frac{1}{2}$.	$4\frac{3}{4}$—5
1.	Little full, wants briskness	Strong liquor, not fine ...	Rather thin wants briskness	Thin.
2. ...	Little full.	Little full dull ...	Thinnish, dull ...	Very thin.
3.	Wants quality	Little full. wants quality	Thin Softish ...	thinnish.
4.	Thinnish	Fairly strong wants ... briskness	Dull liquor	Dull liquor.
5.	Thinnish	Rather full, dull ...	Very thin	Thin liquor.
6.	Very thin	Rather thin soft ...	Very thin	Very thin.
7. ...	Very thin	Little full	Very thin	Very thin.
8.	Very thin	Thin softish ...	Very thin	Thin liquor.

APPENDIX VIII.

Table showing the results of experiments with various Chemical and other manures at Larsingah, Cachar, in 1892.

No. of plants Per $\frac{1}{2}$ acre.	Plot.	Manure.	Quantity of manure.	No. of Pluckings.	Weight of leaf.	Cost. Rs.	As.	P.
1696	1	Sulphate of Potash ...	$\frac{1}{2}$ cwt.	28	927	7	9	3
1677	2	Ditto and Bone dust	$\frac{1}{2}$ cwt. S of K; 1 „ Bones	28	811	11	8	6
1683	3	Blank		28	843	......		
1630	4	Bone dust ...	1 cwt.	29	708	7	5	0
1700	5	Bone dust and Oil cake	1 cwt. Bones; 5 „ cake	29	762	16	7	6
1651	6	Sulphate of Potash, Bone dust, and Oil cake	$\frac{1}{2}$ cwt. S of K; 1 „ Bones; 5 „ cake ...	29	699	20	9	0
1668	7	Nitrate of Potash ...	$\frac{1}{2}$ cwt. ...	28	624	10	5	6
780	8	Blank		28	692	......		
1790	9	Nitrate of Potash and bone dust ...	$\frac{1}{2}$ cwt. N of K; 1 „ Bones	28	795	14	4	9
1770	10	Lime	6 maunds ...	28	757	11	5	9
1560	11	Sulphate of Potash ...	$\frac{1}{2}$ cwt. ...	28	586	7	9	3
1690	12	Ditto and Bone dust.	$\frac{1}{2}$ cwt. S of K; 1 „ Bones	28	722	11	8	6
1635	13	Blank		28	654	......		
1708	14	Bone dust ...	1 cwt. ...	28	830	7	4	9
1570	15	Bone dust and Oil cake	1 cwt. Bones; 5 „ cake ...	28	762	16	7	9
1655	16	Sulphate of Potash, bone dust, and Oil cake	1 cwt. Bones; 5 cwt. cake...	28	747	20	9	0
1555	17	Nitrate of Potash ...	$\frac{1}{2}$ cwt. ...	28	696	10	5	6
1661	18	Blank		28	774	......		
1632	19	Nitrate of Potash and Bone dust ...	$\frac{1}{2}$ cwt. N of K; 1 „ bones	28	685	14	4	9
1604	20	Lime	6 maunds ...	27	648	11	5	9
1653	21	Bhil soil ...	about 6 inches all over ...	27	662	......		

Abstract of Cost :—

Manure freight to garden	Rs. 91	8	6
Lime and Oil cake (local)	„ 51	14	9
Coolies for applying manure	„ 55	7	6
Total ...	Rs. 198	14	9

APPENDIX IX.

AMLUCKIE TEA ESTATE, ASSAM.

Table of Manurial Experiments, 1891.

No. of plot of 1 acre.	Yield of tea to 30th June per acre lb.	Yield of tea from 30th June to 13th September per acre lb.	Total Yield of Tea per acre lb.	No. of hoeing.	Description of manure.	No. of garden.
Nos.						
1 & 3	64½	376	440½	5	1 cwt. of Sulphate of Potash per acre	4 Old tea.
4 & 6	65¼	369	434¼	5	1 cwt. Nitrate of Potash per acre.	Ditto.
7 & 9	51½	367	418½	5	1 cwt. Sulphate of Potash, 3 cwt. ground Bones per acre	Ditto.
2, 5, & 8	52½	333½	385⅚	5	Not manured ...	Ditto.
10, 11, 12, & 13	47½	271¾	319¼	5	10 mds. incinerator ash per acre.	4 Young tea.
14	72	404	476	5	Bhil Soil ...	......
15	71	354	425	5	Not manured ...	......
16, 17, & 18	34⅔	257⅓	292	5	20 mds. incinerator ash per acre.	4 Young tea.

APPENDIX X.

(*a*). KONDOLI TEA GARDEN, ASSAM.

Table showing the amount of leaf plucked from special manured plots, from June to September 30th 1891, 4 plots of one acre each manured in June 1891.

PLOT No. 1.	PLOT No. 2.	PLOT No. 3.	PLOT No. 4.		
Blank.	Sulphate of Potash.	Nitrate of Potash.	No. 3. Mixture.	Total.	REMARKS.
Mds. Srs. 16 13	Mds. Srs. 16 20½	Mds. Srs. 16 5½	Mds. Srs. 16 4½	Mds. Srs. 64 3½	

Plant 12 years old, Hybrid, even, plots 2400 plants each.

(*b*). LANGTENG TEA GARDEN, ASSAM.

Table showing the amount of leaf plucked from special manured plots of one acre each from 15th June to 30th November 1891.

Plot No. 1. Nitrate of Potash.	Plot No. 2. Sulphate of Potash.	Plot No. 3. No. 3 Manure.	Plot No. 4. Blank.	Plot No. 5. Nitrate of Potash.	Plot No. 6. Sulphate of Potash.	Plot No. 7. No. 3 Manure.	Plot No. 8. Blank.
Mds. Srs.	Mds. Srs.	Mds. Srs.	Mds. Srs.	Mds. Srs.	Mds. Srs.	Mds. Srs.	Mds. Srs.
29 15	28 39	29 39	24 15	23 30	26 26½	26 28	26 30

Jut of plants, good hybrid; number of plants, each acre 2400 and the quality of this land perfectly even to all appearance.

(*c*). BORGHAT TEA GARDEN, ASSAM.

Table showing the amount of leaf plucked from special manured plots of one acre each, from 15th June to 30th November 1891.

Plot No. 1 Nitrate of Potash.	Plot No. 2 No. 3 manure.	Plot No. 3 Sulphate of Potash.	Plot No. 4 Blank.	Plot No. 5 Nitrate of Potash.	Plot No. 6 No. 3 manure.	Plot No. 7 Sulphate of Potash.	Plot No. 8 Blank.
Mds. Srs.	Mds. Srs.	Mds. Srs.	Mds. Srs.	Mds. Srs.	Mds. Srs.	Mds. Srs.	Mds. Srs.
26 14	25 31	24 15	24 26	25 36	24 26	23 27	26 18

Plant—Hybrid not formerly manured.
Plants—2400 plants each.
Quality of land—even.

APPENDIX XI. (*a*).

Statement of Experiments with Manures, &c., on portions of Doloo Tea Garden, Cachar,

Number.	Description of portion of Garden experimented on and the Manure used.	Date when Manure was applied.	Quantity of Manure used.		Area experimented on acres.	Number of Tea Bushes.	Number of Vacancies.	Percentage of Vacancies.	1872.		1873.	
			⅌ Bush. ℔s	⅌ Acre. ℔s					Tea yielded. Total ℔s	Tea yielded. Rate ⅌ acre. ℔s	Tea yielded. Total ℔s.	Tea yielded. Rate ⅌ acre. ℔s.
1	Portion of China Garden planted 3′×3′ manured with cow-dung and sweepings from coolie lines.	March 1872	8	37696·96	·198	933	27	2·812	151	763·131	175	886·36
2	Do. do. manured with Cirencester manure.	Ditto	1	4611·1	·198	913	47	4·895	140	707·07	169	856·06
3	Do. do. after hoeing covered over with sweepings of Bag or Bheel Soil.	Ditto	....	....	·198	914	46	4·791	113	570·70	135	681·81
4	Do. do. after hoeing a layer of jungle was placed between the bushes in the rows.	Ditto	....	....	·198	936	24	2·5	123	623·73	114	575·75
5	Do. do. ordinary cultivation not manured.	Ditto	....	....	·198	939	21	2·187	112	565·65	99	500·00
6	Do. do. ditto ditto ...	Ditto	....	....	·198	937	23	2·395	127	641·41	110	555·5
7	Do. do. West side of Bungalow with Dr. C. Brown's Fertilizer.	March 1873	4 oz.	1176·47	·017	80	2	2·439	...	......	21	1235·35
8	Do. do. close to No. 7 not manured ordinary cultivation.	Ditto	....	....	·227	1,016	82	7·468	...	......	146	644·27
9	Do. planted 4′×4′ (North Garden) manured with Dr. C. Brown's Fertilizer.	March 1874	2·414 oz.	358·705	24·98	59,380	8,653	12·718	...	......	...	......
10	Do. do. close to No. 9 not manured ordinary cultivation.	Ditto	....	....	2·31	5,380	854	13·694	...	......	...	......
11	Do. planted 3′×3 near "Serasings Teelah" manured with oil-cake.	March 1875	1 ℔	4376·4	5·085	22,254	2,358	9·584	...	......	...	......
12	Do. do. East of Indigenous manured with Dr. C. B.'s Fertilizer.	March 1876	5·101 oz.	1417·538	9.48	42,151	3,734	8·137	...	......	...	......
13	Do. planted 4′×4′ at Mainaghur manured with oil-cake.	Ditto	1 ℔	2710	·500	1,355	8	·586	...	......	...	......
14	Do. do. at Mainaghur ordinary cultivation not manured.	Ditto	....	....	·500	1,345	18	1·320	...	......	...	......
15	Do. planted 3′×3′ manured with oil-cake.	Ditto	1	4833·3	·198	957	3	·312	...	......	...	......
16	Do. do. ordinary cultivation not manured.	Ditto	....	....	·198	944	16	1·6	...	......	...	......
17	Do. do. manured with oil-cake ...	Ditto	1	4722·2	·198	935	25	2·604	...	......	...	......
18	Do. do. ordinary cultivation not manured.	Ditto	....	....	·198	936	24	2·5	...	......	...	......
19	Do. do. manured with oil-cake ...	Ditto	1	4661·61	·198	923	37	3·854	...	......	...	......
20	Do. do. ordinary cultivation not manured.	Ditto	....	....	·198	935	25	2·604	...	......	...	......
21	Do. do. on "Big Teelah" and Coffee "Teelah" manured with oil-cake.	April 1876	1	4214.49	13·040	54,957	8,160	12·77	...	......	...	......

Doloo Tea Garden, Cachar:
9th March 1877.

APPENDIX XI. (*a*).

ortions of Doloo Tea Garden, Cachar, during the years 1872, 1873, 1874, 1875, and 1876.

	Percentage of Vacancies.	1872.		1873.		1874.		1875.		1876.	
		Tea yielded.		Tea yielded.		Tea yielded.		Tea yielded.		Tea yielded.	
		Total lbs	Rate ℔ acre. lbs	Total lbs.	Rate ℔ acre. lbs.	Total lbs.	Rate ℔ acre. lbs.	Total lbs.	Rate ℔ acre. lbs.	Total lbs	Rate ℔ acre. lbs
7	2·812	151	763·131	175	886·36	157	792·92	...	....	...	......
7	4·895	140	707·07	169	856·06	143	722·2	...	....	...	......
6	4·791	113	570·70	135	681·81	143	722·2	...	....	...	......
4	2·5	123	623·73	114	575·75	126	636·36	...	....	...	......
1	2·187	112	565·65	99	500·00	132	666·6	...	....	...	......
3	2·395	127	641·41	110	555·5	153	772·72	...	....	...	......
2	2·439	...	......	21	1235·35	16	1000·00	...	....	...	......
2	7·468	...	......	146	644·273	139	612·334	...	....	...	......
3	12·718	...	......	...	......	12,346	494·27	9,681	387·59	...	......
4	13·694	...	......	...	......	918	397·4	862	373·16	...	......
8	9·584	...	......	...	......	...	....	4,593	903·244	3,208	631·072
4	8·137	...	......	...	......	...	....	...	....	5,460	576·00
8	·586	...	......	...	......	...	....	...	....	307	614·00
8	1·320	...	......	...	......	...	....	...	....	214	428·00
3	·312	...	......	...	......	...	....	...	....	212	1070·70
6	1·6	...	......	...	......	...	....	...	....	124	636·36
5	2·604	...	......	...	......	...	....	...	....	193	974·74
4	2·5	...	......	...	......	...	....	...	....	99	500·00
7	3·854	...	......	...	......	...	....	...	....	159	808·08
5	2·604	...	......	...	......	...	....	...	....	109	550·50
0	12·77	...	......	...	......	...	....	...	....	9,065	695·168

Remarks.

Cost of Manures per acre.

Bushes planted 3 × 3 feet.

Oilcake 1lb. per Bush or 60 maunds of 80 lbs. per acre, 60 mds. at as. 12 per maund ...	Rs.	45 0
Landing and carriage at garden ...	,,	6 0
Laying on	,,	9 0
Total per acre ...	Rs.	60 0

" Tea Fertilizer " 4oz. per Bush or 15 mds. of 80 lbs. each per acre.

At cost per ton in England	Rs.	125 0
Freight to Calcutta	,,	25 0
Freight to Cachar	,,	15 0
Cost at Garden per ton or Rs. 6-10 per md.	Rs.	165 0

15 mds. at 6-10 per md.	Rs.	99 6
Landing and carriage at Garden ...	,,	1 8
Laying on	,,	9 0
Total per acre ...	Rs.	109 14

Cost of manures per acre bushes planted 4 × 4 feet.

Oil-cake 1lb per Bush or 34 mds. (of 80 lb) per acre.

34 mds. at as. 12 per md.	Rs.	25 8
Landing and carriage at Garden ...	,,	3 8
Laying on	,,	5 0
Total per acre ...	Rs.	34 0

" Tea Fertilizer " 4 oz. per Bush or 8 mds. (of 80 lbs) per acre.

8 mds. at 6-10 per md.	Rs.	53 0
Landing and carriage at garden ...	,,	1 0
Laying on	,,	5 0
Total per acre ...	Rs.	59 0

Mr. Gillanders tells me that apparently the " Tea Fertilizer " was exhausted by the end of July, and it would appear to require that less at a time should be given, the 4 or 5 oz. at say 3 different times during the growing season.

But the oilcake is a much better manure both in comparison in these tables and in the actual appearance of the bushes themselves. I am taking the price of the oil-cake at 12 annas per maund, but hitherto I have purchased at less—10 and 11 annas.

I may be mistaken in the price of the "Tea Fertilizer," but I think I once had it in a letter that £12-10 was the cost price in England.

(Sd). Wm. Aitchison.

APPENDIX XI. (*b*).

Statement of Experiments with Manures, &c., on portions of Doloo Tea Garden, Cachar, during the years 1878 & 1879.

Number.	Description of portion of Garden experimented on and Manure used.	Date when Manure was applied.	Quantity of Manure applied.		Area experimented on acres.	Number of Tea Bushes.	Number of Vacancies.	Percentage of Vacancies.	1878. Tea Yielded.		1879. Tea Yielded.	
			℘ Bush ℔s.	℘ Acre ℔s.					Total ℔s.	Rate ℘ acre ℔s.	Total lbs.	Rate ℘ acre ℔s.
7	Portion of China Garden planted 3′ x 3′ on the Banji Tila manured with Oil-cake.	March 1878	1	4926·	·25	1074	136	11·24	159	636·	126	504·
8	,, ,, Crushed Bones.	March 1878	1	3980·	·25	977	233	19.25	146	585·	115	460·
9	,, ,, Dr. Campbell Brown's Tea Fertilizer.	March 1878	6 oz.	252·25	·25	1009	201	16·61	114	459·	119	476·
10	,, ,, Oil-cake.	March 1878	1 ℔·	3972·	·25	993	217	17·93	119	477·	106	424·
11	,, ,, not manured.				·25	1015	195	16·11	92	369·	108	432·
12	,, ,, Bone Dust	March 1878	1 ℔·	4032·	·25	1008	202	16·69	128	515·	119	476·
13	,, ,, Dr. C. B.'s Tea Fertilizer	March 1878	2 oz.	128·12	·25	1025	185	15·28	111	446·	116	464·
14	,, ,, Crushed Bones and Bone Dust mixed.	March 1878	1 ℔·	4208.	·25	1007	193	15·95	135	541·	111	444·
15	,, ,, not manured				·25	997	213	17·60	99	398·	112	448·

REMARKS.—These second year's experiments are very perplexing, and I can make almost nothing out of them. Both plots manured with Dr. Campbell Brown's "Fertilizer" have increased, but so have both plots which have not been manured at all. Leaving out No. 7 which, as I said last year, has a special advantage over the other plots in being better soil and having fewer vacancies, the highest yields areNo. 9—6 oz. Dr. Campbell Brown's Fertilizer—and No. —21 lb. Bone Dust. After these comes No. 13—2oz. Dr. Campbell Brown's Fertilizer—Then very near to this is No. 8—1℔ Crushed Bones. The next but considerably behind is No. 15 not manured, and the worst of all is No. 10—1℔ Oil-cake. I fear this is not reliable, for I have always before found that "Oil-cake-manured" showed an increase over "non-manured" in the second as well as the first year.

DOLOO TEA GARDEN, CACHAR :
15th January 1890.

(Sd.) WM. AITCHISON.

APPENDIX XI. (*c*).

DOLOO TEA GARDEN, CACHAR.

Table showing the yield of leaf from plots ½ acre each, manure applied in March 1892. Soil a light loam with gravelly subsoil—plants, China, 25 years old; rainfall, 159·31 inches—vacancies, 12 per cent.

Plot.	Manure.	Amount. per acre.	Weight of Green Leaf.	Weight of Tea.	REMARKS.
			lbs.	lbs.	lbs.
1	Bone dust ...	2 cwt.	1,289	316	
2	No manure ...	...	1,375	340¼	Excess 24¼
3	Bone dust ...	2 „	1,256	310	
4	No manure ...	...	1,349	329½	„ 19½
5	Sulphate of potash ...	2 „	1,485	365¾	„ 27½
6	No manure ...	...	1,372	338¼	
7	Sulphate of potash }	1 „	1,278	321	
	Oil-cake ... }	2 „	...	...	
8	No manure ...	...	1,289	330¼	„ 9¼
9	Bone dust ... }	2 „	1,075	262¼	
	Oil-cake ... }	10 „	...	...	
10	No manure ...	...	1,164	289¾	„ 27½
11	Bone dust ... }	2 „	1,007	271	
	Oil-cake ... }	10 „	...	...	
12	No manure ...	...	1,164	296½	„ 25½
13	Sulphate of potash }	1 „	1,338	340	
	Bone dust ... }	2 „	...	...	
	Oil-cake ... }	10 „	...	...	
14	No manure ...	...	1,383	348	„ 8
15	Same as No. 13 ...	as No. 13.	1,380	339½	„ 20½
16	No manure ...	...	1,230	309	
17	Lime ...	6 Mds.	1,380	346	„ 7¼
18	No manure ...	...	1,330	338¾	

APPENDIX XII. (*a*)

Table showing the value per unit (1 per cent. per ton) of various manurial constituents, as given in the journal of the Society of Chemical Industry, Vol. VII., p. 100, 1888.

Manure.	Price per unit (English Currency).		
	Phosphate.	Ammonia.	Potash.
	s. d. to *s. d.*	*s. d.* to *s. d.*	*s. d.*
Phosphates (Bones) ...	1 8 ,, 1 6	10 0 ,, 0 0	......
,, (Guano) ...	1 9 ,, 0 0	11 0 ,, 14 0	......
Superphosphates (dissolved)...	2 0 ,, 1 8	10 0 ,, 0 0	......
,, (undissolved)...	1 6 ,, 1 3	......	......
Bone Super. (pure) ...	3 0 ,, 0 0	......	......
Potash (dissolved compounds)	......	......	3 3

APPENDIX XII (*b*).

Table showing the guaranteed percentage of the various constituents in different manures, their value per unit, and the cost of the manure per ton; the latter is obtained approximately by multiplying the percentages by the value per unit of the different constituents.

Manure.	Guaranteed percentage.	Value per unit.	Price per ton.
		s. d.	£ s. d.
Sulphate of Ammonia ...	24 °/₀ Ammonia.	10 6	12 15 0
Nitrate of Soda 95 °/₀ ...	19 °/₀ ,,	9 6	9 0 0
Castor Cake dust ...	5·5 °/₀ ,,	12 6	3 10 0
Rape Cake dust ...	4·5 °/₀ ,,	17 0	4 5 0
Horn dust	14 °/₀ ,,	10 6	7 7 0
Shoddy and ground Leather	12 °/₀ ,,	6 0	3 10 0
Dried blood	15 °/₀ ,,	10 9	8 0 0
Chloride of Potash 80 °/₀ ...	50 °/₀ Potash.	3 3	8 0 0
Sulphate of Potash 50 °/₀ ...	27 °/₀ ,,	3 3	4 10 0
Kainit	12 °/₀ ,,	3 0	1 13 0
Nitrate of Potash 85 °/₀ ...	40 °/₀ ,, 14 °/₀ Ammonia.	4 0 12 6	16 10 0
Ground Charlestown Phosphate	54 °/₀ Phosphate	— 10	2 5 0
Basic Slag meal ...	40 °/₀ ,,	— 10	1 12 6